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PREFACE

Government funds should be expended to further Canada's economic and social objectives in an effective manner, with an efficient allocation of resources among competing programs. This goal requires a systematic approach to the problem of evaluating and selecting individual government projects. One analytical tool that yields information useful in public project evaluation and selection is benefit-cost analysis.

The Treasury Board Secretariat has been actively involved in fostering the use of benefit-cost analysis by individual government departments, while also carrying out occasional in-house benefit-cost studies of major government expenditure programs. Such analysis forms an integral part of the Planning Programming Budgeting System (PPBS) introduced by the Canadian government in 1966. PPBS differs from traditional forms of government budgeting in its concentration on the results or consequences of government activity rather than simply on resources required. It depends heavily on intensive studies of feasible alternative ways to attain defined government objectives with a view to achieving the greatest benefit for a given cost or, conversely, a given objective at minimum cost. Benefit-cost analysis is one quantitative technique that has proved to be of considerable value and usefulness within this PPB framework.

Compared to its predecessor, *Guide to Benefit-Cost Analysis,* published by the Queen's Printer in 1965, but originally prepared as a background paper to the 1961 "Resources for Tomorrow" Conference, the present *Guide* gives a more complete and up-to-date treatment of benefit-cost analysis. The basic methodology is discussed in detail (with extensive reference to the current literature) in order to provide readers with a firm grasp of the underlying conceptual framework. By identifying the similarities between benefit-cost analysis and other common techniques used in financial or market analysis, the *Guide* hopes to dispel any aura of mystique often associated with benefit-cost analysis. Both theoretical and practical issues and difficulties frequently encountered in benefit-cost analysis are carefully treated. The present *Guide* aims to achieve some degree of uniformity in application and comparability in results when benefit-cost analysis is carried out by different departments or agencies. At the same time, it must also be recognized that benefit-cost analysis is still far from being a set of mechanical routines to be applied indiscriminately to any project. This *Guide* has the modest goal of providing readers with a good comprehension of the general conceptual framework and the fundamentals of benefit-cost analysis: it is not a detailed manual or treatise explaining what and how benefits and costs are to be measured in all cases.

The Treasury Board Secretariat firmly believes that more and better benefit-cost analyses will be necessary ingredients in decisions on allocating government funds. Benefit-cost analysis is, of course, in no way a substitute for judgment, but for many decisions it is a prerequisite to exercising good judgment.

This *Guide* does not pretend to have the "last word" on benefit-cost analysis. The techniques of measurement are still in a state of evolution, and work remains to be done in refining them. The Treasury Board Secretariat will maintain a continuing interest in monitoring and assessing new developments in benefit-cost methodology, and it is hoped that this *Guide* will have some impact in stimulating further thinking and discussion of issues that remain to be resolved.

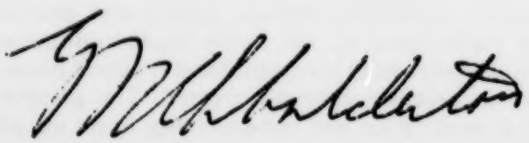
In the meantime, the *Guide* will perhaps also illustrate the perspective from which benefit-cost analysis supporting Treasury Board submissions may be assessed. It is frankly skeptical of adjustments by which claimed or measured benefits are scaled up to reflect alleged "multipliers", or costs

written off to reflect the employment of allegedly unemployed resources. While admitting the theoretical legitimacy of such adjustments in some cases, this *Guide* takes the position that the burden of explicit and persuasive proof rests with the analyst who proposes to deviate from the basic data of the project.

Indeed, the approach of the *Guide* is based on the conviction that the first essential of any analysis in support of government project proposals must be the recognition that the resources required come from other uses, and hence the demonstration that they can be more effectively employed in the project in question at the prices and discount rates prevailing in the market and the private sector. Such a stringent demonstration will not, of course, be definitive or decisive either way; informed judgment and ultimately political decision will be required. But analysis which does not provide the data for assessment of this preliminary point can hardly be considered adequate to support more refined judgments on social valuations.

Thus this *Guide* is offered in the hope that benefit-cost analysis can be seen for what it is: neither a miraculous new methodology replacing old-fashioned wisdom, nor a misguided (and misleading) attempt to reduce all things political and social to the straitjacket of dollar figures, but simply a consistent application of a common-sense approach to bringing before Ministers and senior officials the basic data relevant to serious assessment of investment projects in the public sector. It would be foolish to pretend that such data are all that matter in the final decision; it would, however, be irresponsible to proceed as if they mattered not at all. This *Guide* describes an accepted and consistent framework within which to bring them forward.

I commend it to the attention of all departments and agencies, as part of the overall management system within which departments, and Treasury Board, can discharge their fundamental duty to ensure that the nation's resources are employed frugally and effectively in public-sector programs.



G.F. Osbaldeston
Secretary of the Treasury Board

CHAPTER I

INTRODUCTION

Background

Benefit-cost analysis is a method of evaluating the relative merits of alternative public investment projects in order to achieve efficient allocation of resources. It is a way of identifying, portraying and assessing the factors which need to be considered in making rational economic choices. It is not a new or mysterious technique. In principle, it entails little more than adjusting conventional business profit-and-loss calculations to reflect social instead of private objectives, criteria, and constraints in evaluating investment projects. (This is not to say, of course, that this change in point of view is altogether easy to carry out.)

Benefit-cost analysis is used in many parts of the world as the fundamental technique for public investment project evaluation. In Canada, it has been used increasingly by government departments and agencies, following the publication of the *Guide to Benefit-Cost Analysis* in 1965[1] and the introduction of the Planning Programming Budgeting System (PPBS) by the Canadian government in 1967. However, the principles of benefit-cost analysis were described only briefly in the 1965 *Guide,* and the focus of the document was mainly on natural resource development. As a consequence, applications of benefit-cost analysis in other areas of government concern, and guidelines useful in benefit-cost analyses in such areas, were relatively neglected. The present *Benefit-Cost Analysis Guide* is designed to rectify some of the omissions in the 1965 *Guide.*

The main objective of this *Guide* is to outline the analytical framework underlying benefit-cost analysis by setting forth a consistent body of concepts, definitions and assumptions. Although the basic methodology and the uses and limitations of benefit-cost analysis are described, it is important to emphasize that benefit-cost analysis is not simply a recipe of routine techniques to be applied mechanically. Considerable attention and care must be given to the particular features of the measurement problems of each project. For this reason, the term "guide" is used advisedly. Increased departmental freedom from detailed central agency control carried with it increased responsibility to ensure that resources are effectively utilized in programs which are responsive to social goals. This *Guide* should be a useful tool in enabling departments to assume this increased responsibility. The adoption of the basic analytical framework presented here should help to improve the quality of the information available to decision-makers and thus contribute to a better allocation of the nation's resources.

Benefit-cost analysis as an analytical method

When a private firm evaluates the merits of alternative business investment projects, it typically begins by examining the technical feasibility of the different projects. The next step involves a comparison of the estimated stream of benefits in the form of revenue with the estimated stream of costs over the expected economic life of the investment. The streams of benefits and costs occurring over time are compared by discounting them at some selected interest rate to arrive at the present value of benefits and costs. It is then a simple matter to estimate what an investment will add to the "net worth" of the firm by subtracting the present value of costs from the present value of benefits.

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[1] W.R.D. Sewell et al., *Guide to Benefit-Cost Analysis* (Ottawa, Queen's Printer, 1965). Originally prepared as a background paper for the Resources for Tomorrow Conference held in 1961.

Basically, benefit-cost analysis in the public sector is designed to deal with problems that are very similar to those of business investment decisions, where "lumpy" initial capital outlays are required and the benefits are spread out over many years into the future. In this sense, therefore, benefit-cost analysis is not a new system or technique. It requires technical feasibility and engineering studies to establish the basic data. It compares estimated benefits and costs on a present-value basis by means of an appropriate discount rate. However, benefit-cost analysis differs from purely technical and financial analysis in several important aspects.

Firstly, while business investment decisions are made to enhance the interests of the shareholders and/or the managers of the firm, benefit-cost analysis takes a much wider perspective by assessing the impact on the country as a whole. Misallocation of resources will result if public investment projects are appraised in terms of only technical and financial feasibility, without regard for the benefits and costs to the whole country. The range of benefits and costs that must be considered in public investment project appraisal is therefore much wider. For example, consider a project that provides a cheaper transportation service, but also generates environmental costs in the form of noise and air pollution. In such a case, benefit-cost analysis will have to consider the project's environmental costs, which are likely to be ignored in private financial calculations.

Secondly, the benefits and costs considered in financial analysis are both expressed in dollar terms. The valuation of the benefits and costs arising from public investment is usually more difficult. In many cases, the outputs of public investment projects are provided free of charge to the public. Benefit-cost analysis then requires that dollar values be imputed to these outputs, usually by estimating what consumers are willing to pay for them.[2]

Similarly, where the inputs of projects do not have market prices, the dollar values of the inputs must be estimated. Furthermore, market-determined prices of inputs and outputs sometimes may not reflect true social costs and benefits. Accordingly, the dollar benefits and costs may have to be adjusted to reflect this discrepancy.

Uses and limitations of benefit-cost analysis

The objective of benefit-cost analysis is to compare social benefits and costs of public investment projects using a common measuring rod: dollars and cents. To the extent that different social objectives and concerns can be measured in money terms, benefit-cost analysis reduces the problem of trade-offs between different objectives to a numerical one. It is fair to say that much of the mystique associated with benefit-cost analysis arises from the need to impute dollar values to benefits and costs. However, the difficulty encountered in imputing money values to disparate benefits and costs is easily exaggerated. The starting point in quantifying benefits and costs in dollar terms is market prices. In the case of imperfect markets, often only very minor adjustments to market prices are necessary or warranted. To estimate values for outputs of public projects that are provided free of charge, market prices for similar private-sector outputs can be used. With a bit of ingenuity and common sense, dollar values of benefits and costs that appear to be difficult to quantify can often be estimated from market information. Take, for example, the noise-pollution cost resulting from building a new airport. To assign a dollar value to this cost, one could examine the differences in property values between areas with similar noise levels and areas without such pollution, to determine the price people are willing to pay to live in areas without noise pollution.

There are, of course, limits within which social objectives can be measured in money terms. An example of a non-efficiency objective (i.e., not measurable in dollar terms) is a more equitable distribution of income. By making it impossible to compare all benefits and costs relevant from a social viewpoint in money terms, non-efficiency objectives indeed impose certain limitations on

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2 See pages 13-15.

benefit-cost analysis. But benefit-cost analysis remains a useful tool in the presence of non-efficiency objectives. The role of benefit-cost analysts in such circumstances is to identify problems of trade-offs between efficiency and non-efficiency objectives and to compile indicators of the extent to which alternative non-efficiency objectives are achieved. If decision-makers are presented with such indicators, along with dollar measures of benefits and costs, they will have the best possible information on which to base their decisions.

Furthermore, the process of conducting a benefit-cost analysis of a project often yields valuable information concerning the project which might not be apparent otherwise. In assessing a project, it is necessary to identify clearly the basic objectives to be achieved by the project, the constraints facing the project, and the alternatives to be considered. This usually leads to more detailed discussions and clearer appreciation of the various aspects of the project, and to the gathering of relevant data to arrive at better estimates of benefits and costs.

Although nothing substantive depends on the particular labels or jargon employed, it is worthwhile to make a distinction between benefit-cost analysis and cost-effectiveness analysis. Generally speaking, cost-effectiveness analysis is used for projects where the aim is to minimize the costs associated with the attainment of any given objective or objectives. While attempts are made to quantify these objectives whenever possible, no substantial effort is exerted in trying to value the objectives or outputs in money terms. The feature which distinguishes benefit-cost analysis from cost-effectiveness analysis is the attempt benefit-cost analysis makes to go as far as possible in quantifying benefits and costs in money terms. However, benefit-cost analysis rarely achieves the ideal of measuring all benefits and costs in money terms, and must therefore be accompanied by indicators of the non-efficiency objectives for decision-making at the political level. The distinction between benefit-cost analysis and cost-effectiveness analysis is therefore merely a difference in degree and not in kind.

An important prerequisite for using benefit-cost analysis is that the projects being considered have negligible impact outside the immediately affected areas of the economy. This form of analysis falls under what is known as partial equilibrium analysis. To assess policies that materially affect prices, outputs, and structure of large parts of the economy outside the immediately affected areas, general equilibrium analysis is the appropriate tool. Examples of general equilibrium analysis that have become widespread in recent years are econometric models and the body of techniques that have been labelled systems analysis. These models consist of sets of equations expressing the relationships among the key variables in the economy, so that the effects of changes in one variable on all other interrelated variables can be traced. The use of such models will be most familiar to the analyst in connection with the simulation of changes in macroeconomic policies. These models have also been deemed appropriate in examining proposed public health programs, where the adoption of measures which reduce debility, mortality or fertility have effects upon the demographic structure of the population and the size of the labour force.

Unfortunately, the distinction between projects which have negligible effects on macroeconomic variables and projects which have significant effects on these variables is by no means clear. Therefore the analyst must determine the circumstances in which the partial equilibrium assumptions which underlie benefit-cost analysis suffice for assessment of a proposed project or policy measure, and when it is necessary to turn to the use of general equilibrium techniques.

Benefit-cost analysis in the PPB framework

Since 1966, the Treasury Board has taken steps to introduce a Planning Programming Budgeting (PPB) approach to resource allocation. One respect in which a Planning Programming Budgeting System (PPBS) is significantly different from traditional forms of government budgeting is in its concentration on the results (outputs) and benefits as opposed to just a consideration of the resources required. Broadly speaking, implementation of PPBS requires the following steps:

- Setting and definition of government objectives;
- Assessment of the extent to which government programs contribute to achievement of the objectives;
- Identification of alternative ways to achieving the objectives;
- Measurement of costs of achieving the objectives;
- Specification of the constraints within which decision-makers must operate; and
- Specification of the criteria to be employed in arriving at a decision.

PPBS stresses the use of analysis at all stages, with strong emphasis on quantitative analysis. Benefit-cost analysis is one technique among many used in an overall PPB framework. It should be clear by now that benefit-cost analysis is designed for a particular kind of problem, that of achieving efficient resource allocation when lumpy initial capital outlays are required and benefits accrue over extended periods of time. The conceptual framework for benefit-cost analysis is, of course, broad enough to allow its application to an existing program as opposed to a proposed project, since to do nothing is an obvious alternative that warrants consideration. Benefit-cost analysis is therefore of primary use in the planning aspect of PPBS.

Role of the Treasury Board

As the Cabinet Committee on the Expenditure Budget and the Cabinet Committee on Management, the Treasury Board is responsible for proposing to the Cabinet as a whole the allocation of the available financial resources among competing public programs and projects and for ensuring that resources are used efficiently. To assist in carrying out these responsibilities, the Treasury Board has introduced a number of management systems over the years. PPBS is one approach that has been adopted to promote efficiency in resource allocation. Other systems that have been implemented are Management by Objectives (MBO) and Operational Performance Measurement System (OPMS). Briefly stated, MBO is an approach to management which places primary emphasis upon the management functions of planning, directing and controlling by organizing work so as to achieve specific objectives in a defined time period. OPMS, on the other hand, is designed to measure the efficiency of departmental operations relative to a base or reference year by determining qualitative measures of operational performance and the effectiveness by which operational activities contribute to the achievement of government objectives. The three systems together – PPBS, MBO, and OPMS – span virtually the entire management process. They are not independent systems. Each of the three systems is designed for certain aspects of the management process which are highly interrelated. They all make extensive use of quantitative techniques of one kind or another. Benefit-cost analysis is one technique that has been frequently used in the PPB framework.

The Treasury Board Secretariat, at the request of Treasury Board and/or the Cabinet, has carried out and will continue to carry out special benefit-cost analyses of projects that do not fall within the jurisdiction or competence of individual departments. But the main objective of this *Guide* is to encourage the use of benefit-cost analysis by departments and agencies. Better information within departments about the expected benefits and costs of proposed projects would improve the quality of departmental proposals submitted to Treasury Board. It would also improve the quality of the expenditure decisions delegated to individual departments.

When properly applied, benefit-cost analysis can be of great assistance in the decision-making process and in achieving efficient use of the nation's resources. But it should be recognized that benefit-cost analysis is an aid to judgment, not a substitute for it. The existence of uncertainties in prospective costs and benefits, and the difficulty or even impossibility of measuring what might be

relevant costs or benefits must be brought to the attention of the decision-maker. The sensitivity of the results to alternate assumptions must be presented. Above all, the analysis must be explicit and open, so that other interested parties can test, criticize or refute whatever assumptions are made by the analyst. If this approach is taken, ministers will have available the most complete information in making their decisions.

Outline of benefit-cost analysis

Before proceeding to discuss the principles and applications of benefit-cost analysis, it seems appropriate at this point to introduce to the reader what benefit-cost analysis attempts to accomplish by identifying its essential elements. Consider, for example, a proposal to pave an existing gravel road. The benefits and costs that are typically considered are listed below:

Costs	Benefits
• Construction cost	• Reduction in vehicle operating costs and driving time
• Maintenance cost of the paved road	• Avoidance of maintenance cost of the gravel road
	• Reduction of dust
	• Increased comfort and safety.

After the costs and benefits have been identified, they have to be quantified in money terms and then compared. Much of the basic data required for quantification purposes can be obtained from engineering and feasibility studies. Since the costs are concentrated at the beginning of the project, and the benefits occur over an extended time-period, it is therefore necessary to convert them into a common measure for comparison purposes. This is done by the use of an appropriate interest factor, or discount rate. The technique of converting benefits and costs that occur over time into their present values is known as discounting. Finally, the present value of benefits are to be compared with the present value of costs in order to determine if the proposal is economically efficient.

The general principles underlying benefit-cost analysis are discussed in detail in Chapter II. While this *Guide* is written for the general reader, some familiarity with basic microeconomics will be helpful to the reader in understanding the concepts of benefit-cost analysis more thoroughly. Chapter III presents the basic steps in carrying out benefit-cost analysis, followed by three case studies.

CHAPTER II

THE CONCEPTUAL BASIS OF BENEFIT-COST ANALYSIS

In undertaking benefit-cost analysis of proposed government expenditures, we are in effect engaging in hypothetical experiments. We wish to estimate what the general welfare of society would be with and without a proposed project in order to estimate what additional benefits and costs it generates. Benefits may be defined as the favourable consequences of public projects; costs as their unfavourable effects.

Traditionally, benefit-cost analysis has focused on the determination of the effects of public projects on total physical production possibilities and consumption opportunities, given the existing stock of resources in the economy. There is considerable agreement among economists concerning the procedures that should be used in evaluating such efficiency, or allocative effects of projects, and an extensive literature exists on applications in most fields of government activity. The following section of this chapter outlines the relevant techniques in this type of analysis and suggests means of dealing with frequently encountered problems.

Of course, government funds are expended with objectives other than those of increasing gross national product or total consumption opportunities. For instance, governments may have the intention of obtaining a more equitable distribution of national income by means of public expenditures. Nor may efficiency and equity be the only goals of government in undertaking public projects. The second section of this chapter will consider the problems in performing benefit-cost analysis where there are multiple objectives in undertaking public projects, and effects which are incommensurate with efficiency have to be considered in the investment decision.

Efficiency criteria in benefit-cost analysis

Some general principles

Economists define an efficient economy as one where any reorganization of production or consumption that helps some part of the economy must hurt another part. In such an economy, total output cannot be increased by transferring factors of production from some firms to others. Nor can some consumers be made better off and none worse off by altering the product-mix of the economy, the distribution of income, or the allocation of time between labour and leisure.

In examining the efficiency of government projects, the objective of benefit-cost analysis is to measure what total production and consumption opportunities would be with and without these public expenditures. Efficiency or allocative benefits are those favourable consequences of projects which represent opportunities to increase production or consumption; the allocative costs are the opportunities for production or consumption foregone because of projects undertaken. It is considered that a project is efficient and should be undertaken if its allocative benefits exceed its allocative costs.[3]

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[3] This criterion of efficiency is also referred to as a test for potential Pareto improvements, that is, everyone in society could be made better off by means of a costless redistribution of the net benefits. Its foundations in welfare economics will be explored in the section on Non-Efficiency Effects.

The implications of the above definitions of allocative benefits and costs require careful analysis. It is most important to realize that these concepts need not be reflected in the accounting data for a project: the latter may exclude items which should be counted as allocative benefits and costs, and may include items which should not be counted as allocative benefits and costs. For example, if public projects are financed by borrowing, the repayment of principal and interest, even though they are relevant for cash-flow purposes, does not represent allocative costs since the real resources used are the same regardless of the method of financing. We shall proceed to describe such differences between the accounting data for a project and the concepts of allocative benefits and costs in outlining the marginal principle which underlies the calculation of allocative benefits and costs, discussing the differences between the real and pecuniary effects of public projects, and considering the valuation of implicit effects of public projects.

1. The marginal principle

We have defined the allocative benefits and costs of public projects as being the opportunities for society to consume and produce gained and foregone as a result of these public expenditures. An implication of these definitions is that we are only interested in valuing the extra, marginal or incremental benefits and costs of government projects. The application of this principle leads to a well-known conflict with the accounting practices employed in estimating the costs of public projects. For instance, where such a project uses facilities that are already in the public domain, conventional accounting treatment requires amortization of the cost of these resources over their lifetimes. The concept of opportunity costs requires a different treatment of such "historical" or "sunk" costs. The opportunity cost principle is well summarized in the ancient economic axiom that "bygones are bygones". The relevant opportunity cost of a facility does not take into account what has been spent on it, but only its highest value in alternative uses. The concept may be illustrated by reference to a recent benefit-cost analysis prepared for the Ministry of Transport on whether to retain and expand a local airport. The author of this study assigned no opportunity cost to the use of the existing runways at the airport (other than for expenditures incurred in their maintenance), his argument being that these runways had no alternative uses and no scrap value. On the other hand, the land on which the airport in question was situated clearly had alternative uses, and was accordingly assigned an opportunity cost in the study.[4]

This example of an investment decision on whether to expand or contract an existing public project raises a further point. In these circumstances, it may be a fundamental error to associate the marginal benefits and costs of the proposed action with average benefits and costs calculated from past experience in the project. There are many reasons why marginal benefits and costs may diverge from the average figures for these items, ranging from less than infinite elasticity of demand for the output of a project to economies of scale in project costs. Failure to take account of the differences between marginal and average costs and benefits constitutes a rather elementary defect of many benefit-cost analyses evaluating the desirability of expanding or contracting public programs.

2. Real and pecuniary effects

In evaluating the efficiency of projects, the analyst must be careful to distinguish their allocative effects from their pecuniary or distributional effects. The former effects alter total production possibilities and consumption opportunities; the latter consequences alter the distribution of total income without changing its volume. In essence, such distributional effects merely make some producers or consumers better off by making others correspondingly worse off. Such distributional effects are often revealed by changes in the relative prices of factors of production, or by changes in asset values.

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[4] Ministry of Transport, *Benefit-Cost Analyses for Local Airports: A Case Study of Oshawa Airport*, by Ronald W. Crowley (Ottawa, March, 1970), Chapter V. While this study brings out the opportunity cost concept, the actual calculation for land cost should not be followed: it ignores increments in opportunity cost which occur if land value appreciates in real terms over time.

Two examples may help clarify the often difficult distinction between the allocative and distributional effects of government projects. In the first place, let us consider the effects of subsidies for the training of workers who would otherwise be entitled to receive welfare payments. In so far as such training allows workers to acquire skills which raise their productivity in employment, it clearly leads to allocative benefits. But any reductions in welfare payments that are attributable to such training do not in themselves constitute allocative benefits to society, because any relief obtained in this way by the general taxpayer constitutes a loss to the former recipient of transfer payments.[5]

As an example of changes in relative prices signalling the occurrence of distributional effects, let us suppose that the building of a public dam leads to increases in the wages of construction workers, the productivity of these workers remaining unchanged. While consumers and businesses engaged in residential and nonresidential construction elsewhere in the economy may be adversely affected by this change in prices, their loss will be offset by a corresponding benefit to the workers concerned. In calculating the efficiency effects of constructing such a public dam, the analyst would accordingly ignore any reallocation of resources brought about in the rest of the economy by this change in the relative prices of factors of production.

The confusion of pecuniary and allocative effects constitutes a primary defect in many analyses of the efficiency of public projects. Indeed, as our subsequent discussion of the so-called secondary benefits of projects will reveal, government agencies in Canada and elsewhere have occasionally added to the confusion by suggesting that some pecuniary effects of projects should be treated as allocative effects. We do not, of course, mean to imply that distributional effects are irrelevant in considering the desirability of government projects, but simply that such effects should be considered separately from any effects of projects on total opportunities for production and consumption.

3. Implicit effects

While an attempt should be made to take account of all substantial allocative effects in evaluations of the efficiency of public expenditures, some of these consequences may be less obvious than others. In particular, analysts have to beware of confining measurement of the allocative effects of projects to the monetary flows associated with these projects. Some of the allocative effects of publicly sponsored projects may not be recorded in terms of market transactions. Such implicit effects may be either internal, devolving on persons undertaking or associated with a particular action, or external, bearing on parties outside or unassociated with the action.

Public expenditures on education and training programs provide good illustrations of the importance of valuing the internal implicit effects of programs. Thus, it is well-known that students incur substantial personal costs for education in the form of earnings they forego because they are in school when they could be working. From the social point of view, such foregone earnings also serve as a proxy for the value of the output sacrificed by society because students are in school when they could be contributing to output. Indeed, foregone earnings appear to constitute approximately one-half to two-thirds of the total allocative costs of university education in Canada, depending on the type of program the student undertakes (for example, arts or sciences, graduate or undergraduate) and whether one adjusts educational inputs for growth over time in the number of students being educated.[6] Similarly, foregone earnings have been estimated to constitute up to

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[5] For further discussion of the allocative effects of changes in transfer payments occurring as a result of training programs, see David Sewell, *Training the Poor* (Kingston, Ontario, Industrial Relations Centre, Queen's University, 1971), pp. 47-48.

[6] See Walter Hettich, *Expenditures, Output and Productivity in Canadian University Education*, Economic Council of Canada Special Study No. 14, (Ottawa: the Economic Council of Canada, 1971), Chapters 3 and 4 and Appendices B and C; David A. Dodge and David A.A. Stager, "Economic Returns to Graduate Study in Science, Engineering and Business", *Canadian Journal of Economics*, Vol. V, No. 2, pp. 182-98, 1972.

one-half of the allocative costs of some types of government-sponsored training programs for workers with low incomes.[7] Clearly, ignoring such implicit costs could lead to major errors in analyses of the allocative effects of public expenditures on education and skill-acquisition.

External effects (also referred to as spillovers, social effects, third-party effects and externalities) constitute another type of implicit effect. These effects are benefits received or costs borne by those not associated with an activity, for which payment is neither given nor received. In the private sector of the economy, decision-makers bent on maximizing their own satisfaction or profit levels may ignore such external consequences, since they are not reflected in the market prices of their transactions. Industrial air and water pollution constitute time-honoured examples of such differences between the social and private costs of transactions. On the other hand, social benefits may also exceed the private benefits accompanying private transactions, as when education undertaken by individuals to increase their earning power has the favourable by-product for society of creating a more informed electorate.

Nor does the private sector of the economy have a monopoly upon transactions which lead to allocative effects on parties not involved in or associated with an activity. Thus, it is claimed that the value of the Great Lakes for recreational and commercial fishing purposes has been lowered by the introduction and spread of lampreys, resulting from the operation of the St. Lawrence Seaway and other man-made canals. Outside Canada, the Aswan High Dam is alleged, among its other consequences, to have lowered the annual sardine catch in the Eastern Mediterranean by 97 per cent.[8] And of course, there are many examples where the upstream disposal of raw sewage by municipalities adversely affects the downstream recreational value of a river and also threatens the health of downstream residents. On the other hand, publicly sponsored projects may also lead to benefits which are not shared by participants in such projects. For instance, vocational training programs for inmates of penitentiaries may reduce recidivism, thereby allowing society to free resources from law-enforcement.

Our definition of external effects suggests an interesting point: effects which are external to those undertaking an activity become internal to more comprehensive decision-making units. Thus, a municipality which pours untreated sewage into a river may be unconcerned about the effects on downstream residents. However, the province whose jurisdiction includes both the polluters and those affected by the pollution may be more concerned with the actions of the offending municipality. Similarly, differences between the external and internal effects of activities, whether undertaken by private parties or provincial and municipal governments, have provided a traditional justification for federal government intervention in the economy on behalf of the public or national interest. It is therefore incumbent on analysts conducting benefit-cost evaluations of projects under consideration by the federal government to take allocative external effects into account, insofar as they are substantial and can be foreseen.

We need to reiterate that the only externalities that should be taken into account in assessing the efficiency of public projects are so-called technological externalities, that is, those that affect total opportunities for production or consumption, as opposed to pecuniary external effects which do not affect total production or consumption. Pecuniary externalities abound; in fact, most of the examples of pecuniary effects that come readily to mind are pecuniary external effects. For instance, losses imposed on other producers because a project bids up the prices of factors of production, raises the prices of products which are complementary to the project's output, or reduces the prices of products which are substitutes for the project's output are all examples of pecuniary external effects. None of these actions affects the physical production possibilities of other producers or the satisfactions consumers can obtain from given resources, and they should be ignored in analyses of the efficiency of public projects.[9]

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[7] See Sewell, *Training the Poor*, pp. 49 and 93.

[8] See Garrett Hardin, "To Trouble a Star: The Cost of Intervention in Nature", *Bulletin of the Atomic Scientists*, (January, 1970), pp. 17-20.

[9] For an extended discussion of this topic, the reader is referred to Roland N. McKean, *Efficiency in Government Through Systems Analysis*, (New York, John Wiley and Sons, 1958), Chapter 8.

Problems of measuring allocative benefits and costs of public projects: the use of shadow prices

In general, benefits should measure the value of additional goods or services produced or the value of cost savings in the provision of goods or services, while costs should measure the value of real resources displaced from other uses. In the absence of implicit effects, monopoly power, price or quantity controls, taxes and subsidies, external economies, and other market imperfections, market prices for outputs will be equal to the marginal social costs, or the value of the resources used to produce these outputs, and market prices for inputs will be equal to the value of their marginal contribution to output. Under such circumstances, market prices will adequately measure allocative benefits and costs.

There are, however, many instances where existing market prices do not accurately reflect the value of market transactions to society as a result of various distortions or because market prices may not even exist. In such situations, it may be necessary to impute the allocative benefits and costs of public projects by either adjusting market prices or estimating what the correct market prices would be. These adjusted or imputed prices are called shadow prices and the technique of imputing values in such circumstances is known as shadow-pricing.

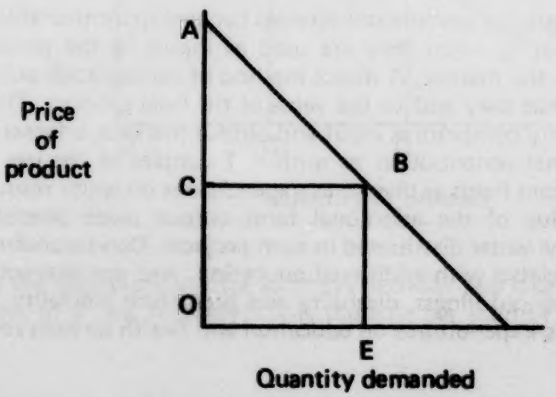
The problem of assigning shadow prices to the outputs of government projects will be treated first in our analysis. Since instances of market failure have provided traditional justifications for the provision of public services, the necessity of assigning shadow prices arises most frequently in the evaluation of outputs of government projects. Moreover, in principle, the problem of valuing the inputs used in projects reduces to a problem of valuing outputs, since the allocative costs of these inputs are the value of what they could produce elsewhere in the economy, as reflected in their market prices. However, important instances where prices may prove unsatisfactory guides to the allocative costs of inputs to public projects will be discussed subsequently in our analysis.

1. Shadow prices for outputs

The principle in estimating shadow prices for the outputs of public projects is to simulate what users would be prepared to pay for the services of these outputs if the reasons for market failure which led to public provision of these goods were overcome and the goods were sold in perfectly competitive markets. This principle is based on the premise that the benefit of consumption is equal to the satisfaction or utility derived by the users, and the price users are willing to pay is the best available measure of that satisfaction. As indicated in Diagram 1, the area under the demand curve, including consumers' surplus (the area ABC) as well as revenue from sales of the product (the area CBEO), is what users would be prepared to pay for the output of a project. After all, users would be prepared to pay for the consumers' surplus they obtain from a product rather than do without the

Diagram 1

Value of outputs of government projects



good. Where a project adds to the total output of a product without significantly affecting its price, the problem of valuing consumers' surplus can be ignored; the output of the project times the market price per unit of output adequately represents its value to users. Where a project is large enough to affect the price of a product, however, account has to be taken of changes in consumers' surplus. The latter problem will be treated subsequently under the heading of "supramarginal change" in prices.

The analyst should realize that it may not be possible to value any of the benefits from some public expenditures. Classic examples are collective-consumption goods, such as lighthouses and radio broadcasting facilities. The consumption of the services of these goods by one consumer does not interfere with consumption by others and it would accordingly be inefficient to charge for their use. Where it is difficult or extremely costly to exclude consumers from using such collective consumption goods, and therefore difficult to charge for the cost of their provision, there is an additional reason for believing that the benefits of these public services cannot be valued in the marketplace. Essentially, the values of such collective-consumption goods and the quantities in which they are supplied have to be determined by the political process.

Benefit-cost analysis and related tools are not entirely useless in these circumstances, however. In the first place, the analyst can assist in the process of valuing collective consumption goods simply by informing the decision-maker of the full costs of providing these goods, and by posing the question of whether such costs would be justified by the benefits. Thus, the amount of government expenditure on functions such as preserving the nation's cultural heritage, reducing alienation among youth, or encouraging basic research in the pure sciences is not unrelated to the costs of implementing these objectives.

Secondly, once the political decision to undertake expenditures on pure collective-consumption goods has been made, cost-effectiveness analysis can be used to ensure that such services are supplied in the most efficient way possible. In the language of military systems analysts, this task has been graphically described as "getting the most bang for the buck".

Finally, not all publicly supplied goods which enter directly into consumption have indeterminate values, even when they have elements of a collective good nature. For example, markets for private recreational facilities may provide the necessary information on prices to evaluate the benefits from public recreational projects. Alternatively, the prices of complementary private goods may provide clues to the value of these public recreational facilities. Thus, to estimate the recreational value (including consumers' surplus) of public parks, demand functions for park services are obtained by using data on the number of travellers to sites from various distances and the costs incurred according to distance travelled. (The latter serve as a proxy for the value of attendance to consumers.) •

The problems of valuing government services become more tractable when these goods serve as intermediate goods; that is, when they are used as inputs in the production of goods which are subsequently valued in the market. A direct method of valuing such publicly supplied intermediate goods is to estimate what they add to the value of the final product. This method derives from the principle that in perfectly competitive input and output markets, a factor of production will be paid the value of its marginal contribution to output. Examples of the use of this method of shadow pricing can be drawn from fields as diverse as expenditures on water resources, education and health services. Thus, the value of the additional farm output made possible by irrigation is used to estimate the price of the water distributed in such projects. Correspondingly, the direct increase in a worker's earnings associated with additional education, and the indirect increase in earnings made possible because of reduced illness, disability and premature mortality, are used to value some of the benefits from public expenditures on education and health services respectively.

A second approach to estimating what users would be prepared to pay for the services of publicly supplied intermediate goods is to value the savings in costs made possible by the provision of such goods. Examples of this method of valuing benefits can be drawn from a number of fields. Thus, disease prevention by public health measures renders treatment costs unnecessary; improved highways save users travelling time, make possible economies in vehicle usage, and reduce accident rates; flood-control projects reduce destruction of property and lives; hydroelectric power schemes reduce the fuel costs consumers would incur if it were necessary to obtain power from alternative sources; the costs of transporting freight by the least costly alternative are used to estimate the cost savings from building canals, and so on.

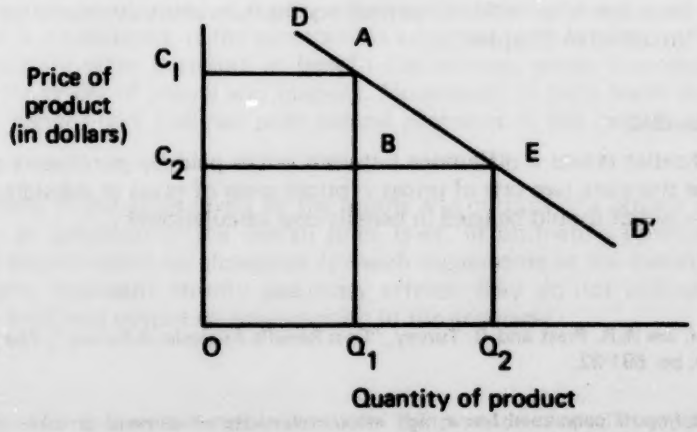
In practice, of course, some or all of the methods outlined above for finding shadow prices applicable to the outputs of public projects may be used simultaneously. As our examples from the fields of health and water resources illustrate, the approaches of estimating cost-savings and the increments in earnings to factors of production may be used to estimate different facets of the value of publicly supplied intermediate goods. Indeed, some public projects, such as those in the water-resource field, may supply both intermediate goods to producers and final goods (like recreational facilities) to consumers. In such cases, the methods of valuing intermediate inputs may be supplemented by the use of price information for privately produced equivalents of the final goods, in order to estimate the total values of the public services being considered.

2. Supramarginal change

Shadow prices also have to be adopted in valuing the benefits and costs of government projects which are sufficiently large so that either their increments to output lower product prices, or their purchases of factors of production raise input prices. The problem of valuing a large increment to output occasioned by a government investment frequently arises in valuing transportation improvements, where large indivisible or "lumpy" investments such as new highways, bridges, canals or tunnels lower the cost of transportation services. The problem is illustrated in Diagram 2.

Diagram 2

Valuation of incremental output from a large government project



In Diagram 2, DD' is the demand curve for journeys between two locations. C_1 is the cost per journey before the building of a new highway; C_2 is the cost per journey after the new highway comes into operation.

Cost savings will accrue to users of the new highway who are diverted from more costly or longer routes. Prominent among such cost reductions may be time savings for travellers and economies in vehicle operation. These cost savings for diverted traffic are reflected in the rectangle C_2C_1AB, which is simply the number of journeys diverted from other routes times the cost savings per journey diverted.

In addition, the lower price of a journey on the new highway leads to additional movement of goods and services and personal travel being generated between the two locations. Diagram 2 indicates that at a cost of OC_2 per journey, Q_1Q_2 additional journeys will be undertaken, for a total cost of Q_1BEQ_2. However, the relevant principle in valuing these additional journeys in a benefit-cost analysis of the new highway is to discover what users would be prepared to pay rather than forego the additional journeys. The relevant area in Diagram 2 is Q_1AEQ_2. In addition to the actual cost of Q_1BEQ_2, users of the highway would also be willing to pay ABE to undertake the Q_1Q_2 new journeys. With a fixed price of OC_2 per journey, the triangle ABE represents consumers' surplus on the additional journeys, and must be valued in estimating the benefits of the new highway.

Comparable problems in valuing inputs occur where a government project is large enough to affect the prices of these factors of production. It is therefore obvious that where government projects affect output (input) prices, the correct value of the increment to output (the cost of inputs) cannot simply be obtained by multiplying the increment in the quantity of output (the quantity of inputs) by either the old or new price of output (inputs), and some price between the old and the new has to be used. Unfortunately, the derivation of the relevant intermediate price depends on whether the good or service in question is a final good or a factor of production used in the project,[10] and on the income elasticity of demand and importance in user budgets of the product or factor of production.[11] In these circumstances, the analyst clearly has to balance off the benefits and costs of obtaining information on the theoretically appropriate prices to use. A pragmatic solution to this problem of differences between old and new prices is that recommended by McKean: "... these magnitudes can be estimated with sufficient accuracy by using a single average price for the incremental outputs and a single average price for the new inputs".[12]

As a final precautionary note to this section on supramarginal change in prices, the reader should recall that benefit-cost analysis is inappropriate for evaluating government projects which have repercussions on prices outside the immediately affected area of the economy. Where a project is large enough to have the latter effects, general equilibrium analysis should be used in its evaluation, as previously discussed in Chapter 1.

3. Taxes and subsidies

Taxes and subsidies create a difference between prices paid by purchasers and prices received by producers. Since there are two sets of prices – prices gross of taxes or subsidies, and prices net of taxes or subsidies – which should be used in benefit-cost calculations?

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10 In this connection, see A.R. Prest and R. Turvey, "Cost-Benefit Analysis: A Survey", *The Economic Journal* 75 (December, 1965), pp. 691-92.

11 Where the output (input) concerned has a high income elasticity of demand or takes up a large part of the budgets of users, a compensated market demand curve must be used to measure consumers' surplus, in order to take account of the different marginal utilities of money for different users.

12 *Efficiency in Government Through Systems Analysis*, p. 170.

The answer depends on whether one is measuring benefits or costs. For example, a sales tax or excise tax on petroleum increases the price to consumers, but it does not increase the amount of economic resources required to produce a given quantity of petroleum. A subsidy, on the other hand, reduces the price to consumers, but it does represent allocative costs since it implies use of real resources. In calculating the benefits of public projects, the proper valuation to use is the price consumers are willing to pay for the output, that is, producer's price plus taxes minus subsidies. In evaluating costs, the answer is less clear-cut. Consider, for example, taxes and subsidies on intermediate inputs. Taxes increase the value of inputs to users above the value of real resources expended in producing them,[13] while subsidies have the opposite effect. In evaluating costs of using intermediate inputs for public projects, the proper measure critically depends on whether the projects' demand for the inputs are met by new supplies, or by diverting them from other uses. If the inputs come from new supplies, the correct measure is the value of real resources expended, which is equivalent to the price paid by other users minus taxes plus subsidies. If the inputs are obtained by depriving other users, the correct measure is the value of the inputs in alternative use, or the producer's price plus taxes minus subsidies.[14]

4. Binding constraints on the use of resources

The advice given in the case of taxes and subsidies also applies where prices are affected by a variety of constraints on the use of resources, if these constraints are expected to be binding in the period covered by a benefit-cost analysis. For example, the cost of inputs for a project may be raised by quantitative controls on imported materials, or because unions and professional associations raise the earnings of their members above what these earnings would be if entry into the occupations concerned were not limited. Alternatively, the prices of the outputs of government projects could be affected by these same restrictions. For instance, government projects could produce outputs competing with imports which were restricted by quantitative controls, or could subsidize the training of labour in occupations controlled by unions or professional associations. If these constraints on prices are expected to persist in the period covered by the analysis, and if the undertaking of the project would mean that more or less of the goods and services concerned would be available to the public, the relevant prices for estimating benefits are what consumers are prepared to pay for them. The relevant prices for estimating costs once again depend on whether the inputs are derived from new supplies or from other uses, and should therefore reflect either the value of real resources required or the value in alternative uses.

5. Movements in price levels

As has been previously indicated, it is only valid to use market prices as a guide to the value of resources whose use is constrained, if the constraint is expected to be binding in the period covered by the analysis. There are other occasions in benefit-cost analysis where time should be taken into account in valuing the prices of inputs and outputs. Movements in price levels over time affecting items entering into benefit-cost analyses pose several problems in this respect which will now be considered.

Changes over time in the price levels of the inputs and outputs of a project may arise because of general inflation or deflation in the overall price level. In estimating benefits and costs for a project, the analyst should make no allowance for such movements in the overall price level. Such price level movements represent strictly pecuniary effects; they do not indicate what impact a project will have on total real output or consumption in the economy.

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13 An exception to this is user taxes collected in return for the provision of specific goods or services by the government, such as highway or bridge tolls.

14 For more on this point, see Arnold C. Harberger, *Project Evaluation: Collected Papers* (Chicago, Markham Publishing Co., 1973), pp. 54-58.

Failure to exclude general price level movements from the data entering into benefit-cost analyses can lead to substantial biases in the results of these analyses. Since the benefits of public projects can only be realized after the costs of these projects are incurred, an allowance for expected inflation in overall price levels will exaggerate the benefits of public expenditures. An allowance for deflation in the general price level will have the opposite effect, that of exaggerating the costs of public expenditures. The net bias involved in basing projections of general price level changes on recent experience should also be obvious, since all major price indices in Canada have undergone annual increases for the last two decades.

To be sure, the need to omit allowances for overall price changes does mean that at least one price used in benefit-cost analyses has to be changed, since the current cost of capital will reflect expected changes in overall price levels.[15] It follows that the interest rate used in deriving present values for future benefits and costs of public projects should also be net of anticipated price movements. The required adjustments to the social discount rate will be discussed in the section on the social discount rate.

The logic of holding prices, and hence the relative values of inputs and outputs, constant in terms of prices prevailing in the base year for which a project's benefits and costs are calculated does require, however, that anticipated changes in relative prices should be taken into account in benefit-cost analyses. Examples of adjustments for expected changes in relative prices can be drawn from evaluations in the fields of education and health services. As noted earlier, the increase in earnings associated with increases in education and reductions in illness, disability, and premature mortality is often used to measure some of the benefits from expenditures in these fields. Many authors have adjusted projections of such increases in earnings levels to allow for expected increases in the productivity of the economy over time.[16]

Avoided treatment costs constitute an additional substantial benefit of disease prevention. In estimating savings from disease prevention, at least one author has allowed for the fact that costs of the services of physicians and hospitals have been rising faster than the Consumer Price Index over time.[17]

Some of the relative price adjustments described, such as allowances for the growth rate in real earnings arising from increased productivity in the economy, can be predicted with sufficient accuracy on the basis of historical experience. As shown in Example 2 of Chapter III, sensitivity analysis can be employed to indicate possible minor variations in what is an expected trend in such real earnings. The analyst is on less firm ground when it becomes necessary to allow for relative price changes in areas where price fluctuation is considerable, for instance, in commodity markets. In commodity markets, uncertainty as to the future movements of relative prices increases with the length of the period for which forecasts are being prepared. Over very short periods of time, futures markets may convey information on expected movements in such relative prices. Projections of commodity price movements over longer time periods require explicit attention to the problem of uncertainty in ways which will be discussed later in this *Guide*.

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15 See William P. Yohe and Denis S. Karnosky, "Interest Rates and Price Level Changes, 1952-69", *Federal Reserve Bank of St. Louis Review* 51 (Dec., 1969): pp. 18-38; John Helliwell, Gordon Sparks and Jack Frisch, "The Supply Price of Capital in Macroeconomic Models", in *Econometric Studies of Macro and Monetary Relations*, ed. Alan A. Powell and Ross A. Williams (Amsterdam, North-Holland Pub. Co., 1973), pp. 261-283.

16 See, for instance, Gary S. Becker, *Human Capital* (New York: National Bureau of Economic Research, 1964), p. 73; Burton A. Weisbrod, "Costs and Benefits of Medical Research: A Case Study of Poliomyelitis", *Journal of Political Economy* 79 (May/June, 1971), p. 535.

17 See Herbert E. Klarman, "Syphilis Control Programs", in *Measuring Benefits of Government Investments*, ed. Robert Dorfman (Washington, D.C.: The Brookings Institution, 1965), pp. 373-74.

6. Shadow pricing of unemployed resources

The application of shadow prices may also be appropriate where existing market prices do not reflect appropriate social judgments about values. In this respect, the existence of unemployed resources poses a major problem in benefit-cost analysis. The most frequently mentioned implications are for the costing of public expenditures. Here, it is often advocated that the costs of inputs which would otherwise be unemployed should not be valued at the market prices of employed resources of similar quality, but rather at shadow prices which reflect the lower social costs of using these inputs. While the argument for applying a shadow price to inputs which would otherwise be unemployed is most frequently made with reference to the labour employed in public projects, it needs to be recognized that the argument also applies to other factors of production.

While the practice of shadow pricing inputs may be appealing when unemployment of resources is widespread, there are a number of practical and theoretical problems associated with the use of this technique.

6a. The timing of project activities

Problems associated with the timing of a project should influence the decision as to whether shadow prices are to be assigned to the use of inputs which would otherwise be unemployed. The relevant cost of an input is its cost at the time it is used. Where expenditures on a project are spread over a period of years, uncertainties in projecting unemployment rates create formidable difficulties for the adoption of realistic shadow prices by the analyst. Problems posed by the timing of expenditures may occur even in estimating the social costs involved in construction of a project, where the practice of shadow pricing is most frequently applied to inputs. Thus, in the case of large public works, intervals of several years may elapse between prior benefit-cost analyses of such projects and the completion of their construction. In such cases, it may be clearly inappropriate to assume that unemployment levels prevailing at the time the analysis of a project is conducted will be the same throughout the period of its construction.

It is also ordinarily assumed that, unless the project area suffers from consistently high unemployment rates over a long period of time, a project's operating costs should be estimated on the basis that it will function in a fully employed economy. This procedure should be followed even if a project is undertaken in times of severe unemployment, unless we have good reason to believe that this unemployment will persist in the future. The consensus on this matter also reflects the assumption that mass unemployment is unlikely to be a characteristic condition of the economy in the late twentieth century.

6b. Shadow-pricing inputs in regional incentive grant programs

In areas where economic activity has been depressed for a considerable period of time, the establishment of a project may serve to lower permanently the number of people unemployed. Indeed, this goal of permanently reducing unemployment is an explicit objective of many regional incentive grant programs. In such cases it is, of course, inappropriate to calculate the operating costs of a project on the basis that full employment will prevail. However, the analyst is cautioned against overestimating the potential of such projects for reducing unemployment. In particular, it is wise to avoid the extreme assumption that there is a one-to-one relationship between the number of jobs created by a project and the reduction in the number of unemployed in a region or locality. Since the latter assumption is often made, particularly in analysis of regional development programs, it is worth examining in some detail.

The argument that in areas where employment rates are high, all of the labour employed on public projects should be treated as reducing unemployment by an equal amount is often referred to as the "chain-reaction" or "trickle-down" principle. There are several steps in this argument. In the first place, it is clear that some jobs may be filled directly by unemployed workers. But even where project jobs are filled by workers who were previously employed, it is claimed that unemployment is reduced eventually by the number of jobs that have been created by the public project.

Thus, it is argued that as formerly employed workers fill project jobs, their previous employers fill the vacated positions and a chain of vacancies is accordingly created in the labour market which ultimately must be filled from the ranks of the unemployed.

The chain reaction argument, however, neglects several aspects of labour market behaviour. In the first place, there may not be a one-to-one relationship between quits and vacancies. A firm may change its production techniques in order to eliminate the position of an employee who has changed jobs. Alternatively, a firm may be forced to curtail its production because of the inability to find a suitable replacement for an employee who has quit. Secondly, the chain-reaction theory effectively postulates the existence of an instantaneous and costless adjustment process. However, very real costs are incurred when vacancies are created and remain unfilled for long periods of time, and when output is sacrificed because of the need to train new workers to fill the vacant positions. Finally, some of the jobs created will inevitably be filled by workers attracted to the area by the prospect of receiving jobs in the public project. Unless there are net surpluses of these immigrant workers in other parts of Canada, projects may therefore only serve to transfer jobs from one area to another.

In general, the degree to which the factors mentioned above invalidate the existence of a costless chain-reaction process will vary according to the proportion of skilled labour utilized in publicly supported projects located in areas where regional incentive grants are available. Numerous studies have shown that the unemployment rates of workers and their skill levels are inversely related.[18] Indeed the labour market for many skilled occupations may be one of full employment, even when national or regional unemployment rates are quite high. Accordingly, the greater the proportion of skilled labour employed on projects supported by regional incentive grants, the higher will be the probability of drawing such workers from the pool of employed workers. This in turn implies that the number of steps in the vacancy chain, and the associated adjustment costs (output sacrifices plus training costs), will increase as the proportion of skilled labour demanded increase.

The higher mobility of skilled labour has also been well documented.[19] Therefore, we might expect that the extent to which project jobs are filled by migrants attracted to an area will be directly related to the skill levels demanded. Furthermore, many firms view skilled-labour shortages as being a problem in depressed areas, and often seek to import such labour from elsewhere. For both of these reasons, the problem of job transfers as opposed to job creation will also be a function of skill levels.

All this suggests that the simplified dynamics of the chain reaction concept abstracts considerably from reality. What are needed are labour-response functions which relate the reduction in unemployment per project job created to various regional and occupational unemployment rate data. Unfortunately, little progress has been made in specifying such functions. About all that can be said is that analysts involved in trying to assess the costs and benefits of projects in depressed regions should make every effort to estimate such relationships, while taking into account the objections to the chain-reaction concept that have been noted.

Assuming that the analyst can determine the extent to which the creation of project jobs reduces unemployment, it is still necessary to assign a shadow price to the labour which would otherwise be unemployed. Since people place a positive value on leisure, it is clearly inappropriate to assume that there is zero opportunity cost in employing labour which would otherwise be

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[18] See Samuel Bowles, *Planning Educational Systems for Economic Growth* (Cambridge: Harvard University Press, 1969) pp. 16-18; Sylvia Ostry and Mahmood A. Zaidi, *Labour Economics in Canada* (Toronto: MacMillan of Canada, 1972), pp. 134-135.

[19] See Bowles, *Planning Educational Systems*, p. 16; Ostry and Zaidi, *Labour Economics*, p. 73.

unemployed. Rather, the correct shadow price of this labour is its supply price, that is, that wage which is just sufficient to get it to work.[20] One might suppose that the supply price of unemployed labour will be functionally related to the level of unemployment insurance benefits and to the average duration of unemployment.[21] The choice of a precise figure, however, will undoubtedly be somewhat arbitrary. Accordingly, any analyst attempting to assign such a shadow price should make his assumptions explicit.

6c. Other problems in shadow pricing unemployed resources

Some further problems with shadow pricing should be noted. In the first place, the analyst is faced with considerable difficulties in applying shadow-pricing techniques consistently to the evaluation of unemployed resources, even where the circumstances are considered to render the use of such shadow pricing appropriate. For instance, given conditions of widespread unemployment, one may be able to assign shadow prices to the construction labour which will be employed in the immediate future on the site of a project. Nor may it be difficult to derive a shadow price for capital equipment used in the project which would otherwise be idle. In such conditions of widespread unemployment, however, it may also be appropriate to regard the intermediate goods, such as materials and fuel, used in a project as being overpriced from a social point of view, since these items may also include labour and capital costs which are above market clearing prices. While consistency of treatment requires that the principle of shadow pricing be extended to the use of these intermediate inputs in a project, the relevant adjustments are clearly not easy to make in practice.

The assignment of shadow prices to the use of otherwise-unemployed resources also has implications for the design of public projects, thereby adding another dimension to the complexity of the problem. Thus, if the shadow price ratios of factors of production differ from their market price ratios, the principle of cost minimization would seem to dictate that the input mix of a project should be adjusted to make more intensive use of the factors with the lower social costs.

In situations where the shadow price of labour does fall below market wages, a further complication arises with regard to evaluating the proper return to capital and hence the opportunity cost of capital. The problem, as Harberger puts it, lies in that

> "... the excess of the actual over shadow wage bill in any industry or sector should be attributed as part of the true economic yield of capital, and should thus tend to produce a discount rate for cost-benefit analysis that is higher than the observed gross-of-tax rate of return to capital."[22]

The task of estimating the appropriate shadow-discount rate in such situations is indeed very difficult, if not impossible, to carry out.

It is also worth noting that, even if the circumstances are appropriate for deriving shadow prices for the use in projects of inputs which would otherwise be unemployed, the resulting estimates of shadow prices for projects may not differ substantially from the actual market costs of undertaking such projects. In the only comprehensive exercise yet undertaken to derive such shadow prices for inputs to public projects, Haveman and Krutilla have attempted to simulate the

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20 This points to an important symmetry in the principles underlying valuation of items entering a benefit-cost analysis: namely, the correct price for an output is what the market is willing to pay for it; the correct price for an input is what its owner is willing to accept in order to supply it.

21 See, for example, E.J. Mishan, *Cost-Benefit Analysis* (London: George Allen and Unwin, 1971), pp. 75-78.

22 "Techniques of Project Appraisal", in *Project Evaluation: Collected Papers*, Arnold C. Harberger, p. 13.

social costs of constructing water-resource projects in various regions of the United States, taking into account regional differences in unemployment levels and utilization of capital.[23] The authors found 'that even in regions where unemployment rates were up to twice the national level, the true social costs of undertaking the projects concerned were typically only 10 to 15 per cent below the actual monetary costs incurred.[24] As one of the authors concludes,

> "At a time when there is much expectation that the incorporation of 'redevelopment benefits' or 'secondary benefits' into benefit-cost analysis will lead to the justification of many projects not otherwise meeting the efficiency criterion, this conclusion should be sobering."[25]

6d. Conclusion

While this *Guide* recommends that, as a general practice, the project analyst should adopt the assumption that resources are fully employed in evaluating the allocative effects of public projects, it is clear that there may be special circumstances in which the analyst is justified in assigning shadow prices to the use of resources which would otherwise be unemployed. One such case, the evaluation of regional incentive programs, has already been mentioned. Another situation might be evaluations of expenditures on remedial education or training programs for workers with low levels of education or skills. Even in conditions of relatively full employment, the latter workers are likely to be unemployed more often and longer than highly educated or highly skilled workers. Accordingly, in evaluating the benefits from such remedial education or training programs, the analyst might well proceed to assume that workers with low levels of education or skills would continue to have substantial periods of unemployment if they did not enter these programs.

However, if the project analyst is of the opinion that special circumstances warrant the assignment of shadow prices to the use of otherwise-unemployed resources, the rationale for making such adjustments must be carefully outlined and defended, and sensitivity analysis should be performed to inform the decision-maker of the consequences of not making the adjustments.

7. The inclusion of multipliers and secondary benefits in benefit-cost analyses

The existence of unemployment also occasionally leads analysts to augment the benefits from government projects, as well as to shadow price their costs. The reason given for augmenting benefits in these circumstances is that if labour which would otherwise be unemployed is used on a public project, the expenditures of the newly employed workers may raise employment and incomes in other sectors of the economy where labour and other factors of production would otherwise be involuntarily idle, and so on in a chain reaction. The total effect of this chain reaction of spending can be summarized in the multiplier analysis often encountered in elementary economics texts.

There is a very thin line between the practice of applying multipliers to project benefits and the practice of including secondary benefits in estimating the allocative effects of projects. Such secondary benefits are usually defined as being the increases in the incomes of factors of production providing services to beneficiaries from the output of a project, or providing services to those who supply inputs for the operation of a project.

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[23] See Robert H. Haveman and John V. Krutilla, *Unemployment, Idle Capacity, and the Evaluation of Public Expenditures* (Baltimore: Johns Hopkins Press, 1968); Robert H. Haveman, "Evaluating Public Expenditures under Conditions of Unemployment", in U.S., Congress, Joint Economic Committee, Subcommittee on Economy in Government, *The Analysis and Evaluation of Public Expenditures: The PPB System, A Compendium of Papers*, 91st Congress, 1st sess., 1969, pp. 547-61.

[24] See Haveman, "Evaluating Public Expenditures", p. 561.

[25] *Ibid.*, p. 561.

Since any distinction between the practices of calculating multiplier effects or secondary benefits appears to rest mostly on the existence of unemployment, we shall analyze their validity where unemployment exists and where resources are fully employed.

7a. Where resources are unemployed

The problem with using multipliers or calculating secondary benefits in circumstances where resources are unemployed is that in benefit-cost analysis one needs to eliminate consequences which are common to alternative courses of government action. Such consequences are irrelevant to the decision-maker who has to choose among alternative courses of action. In this respect, the alternative to undertaking a particular public project may be some other form of government expenditure, which would also employ otherwise-idle resources and have multiplier effects on income and price levels. In a broader context, reductions in taxes or increases in the money supply would similarly be alternatives to undertaking particular government expenditures. These policies would also have expansionary effects on income, employment and price levels. For these reasons, it is recommended that the analyst avoid adding multiplier effects or secondary benefits to benefit-cost analyses of public projects in circumstances where unemployment is widespread.

7b. Where resources are fully employed

In proceeding to evaluate the allocative effects of public projects on the assumption that resources are fully employed, the analyst needs to be particularly careful in two respects. It is necessary to avoid double-counting benefits and costs and, as noted earlier, it is also necessary to avoid confusing the pecuniary effects of public projects with their allocative effects. Errors of these kinds arise when benefit-cost studies include multiplier effects or secondary benefits in situations where resources are fully employed.

In order to clarify the distinction between such side-effects and the true efficiency effects of projects, let us consider the implications of a new superhighway on the allocation of resources within the economy. To estimate the allocative benefits from the highway, we need to estimate what it adds to total production and consumption if the economy is operating at the full-employment level. In practice, this is usually done by estimating what consumers would pay for the savings in time, economies in vehicle usage and additional output made possible by the new highway.

However, it is reasonable to expect that the incomes of local labour and land-owners will also rise as businessmen seek to accommodate the demand from travellers for the services of motels, restaurants and gas stations located in the proximity of the new highway. In comparable fashion, the incomes of workers and profits of businessmen engaged in local road maintenance may also rise. Particularly where factors of production are immobile, the inauguration of such new public projects may lead to large increases in the rents of factors of production; that is, payments over and above those necessary to induce them to work.

It would clearly be erroneous to regard all of these increases in returns to local businesses and workers as benefits from the point of view of the economy. For instance, it is likely that some of the traffic on the new highway will have been diverted from alternative routes. Incomes and asset values along these alternate routes will decline with the diversion of traffic. But even if one eliminates such offsetting changes in incomes and asset values, it would still be incorrect to count as efficiency benefits from the new highway both our estimates of its net value to consumers and any net increases in incomes and asset values accruing to factors of production. Such a procedure would constitute double-counting of benefits, since if our imputations of the value of the new highway to consumers are accurate, we will already have taken account of the payments necessary to attract factors of production into the servicing of the new highway.

7c. Conclusion

The continued application of secondary benefits and multipliers in benefit-cost analyses despite equally persistent ridicule from economists requires explanation. Two reasons for the persistence of these phenomena seem plausible.

In the first place, the reasoning lying behind secondary benefits and multipliers may relate to one of the oldest fallacies in economics: the fact that the jobs provided by a public project are visible while those that would be created by some alternative course of action (such as a tax cut) are less identifiable. This fallacy was exposed over a century ago by the noted French economist Frederic Bastiat. Replying to the proposition that the private misfortune of a shopkeeper in having a window broken was beneficial for national employment, Bastiat argued:

> "Stop there! Your theory is confined to that which is seen; it takes no account of that which is not seen. It is not seen that as our shopkeeper has spent six francs upon one thing he cannot spend them upon another. It is not seen that if he had not had a window to replace, he would, perhaps, have replaced his old shoes or added another book to his library. In short, he would have employed his six francs in some way which this accident has prevented."[26]

Secondly, the continued enthusiasm for secondary benefits and multipliers in benefit-cost analyses may represent a misplaced endeavour to incorporate effects which are entirely relevant in a different context. We have seen that these effects are often pecuniary effects, involving transfers of income from some areas and persons to others. We are therefore not indifferent to such pecuniary effects, although they are irrelevant in estimating what the implications of a project are for *total* production and consumption opportunities in the economy (that is, the efficiency effects of a project). The evaluation of such distributional effects in benefit-cost analyses of public projects will be considered further.

8. How far should shadow pricing be taken?

The analyst has to use judgment in deciding to what extent it is necessary to value implicit allocative effects of government projects, or substitute shadow social prices for actual market prices in benefit-cost analyses of government investments. In both instances of shadow pricing it should be recognized that

> ". . . what is tangible or intangible, measurable or nonmeasurable, is less a matter of what is abstractly possible than it is of what is pragmatically, and at reasonable cost, feasible."[27]

In effect, analysts have to conduct their own benefit-cost evaluation of any possible excursions into shadow-pricing; assessing the probable quality of the data to be obtained against the costs of the exercise. Some guidelines can nevertheless be given concerning the circumstances in which shadow pricing is appropriate and inappropriate.

Other things being equal, the size of the project is an obvious determinant of the extent to which one should quantify implicit effects of projects or consider substituting shadow prices for actual market prices of inputs and outputs. More is at stake in proposed expenditures of $5 million than in proposed expenditures of $50,000.

Of the two types of shadow pricing we have discussed, valuing implicit effects of projects and substituting more appropriate social values for actual market prices, the latter may be more difficult to justify in benefit-cost analyses. As McKean reminds us,

> ". . . markets provide an enormous amount of information at a relatively low cost, even though the information is still short of being perfect."[28]

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[26] *Completed Works of Frederic Bastiat*, 2nd Ed., Vol. 5, Guillaumin et Cie Librairies, Paris, 1863, p. 338.

[27] Burton A. Weisbrod, "Concepts of Costs and Benefits", in *Problems in Public Expenditure Analysis*, p. 261.

[28] "The Use of Shadow Prices", in *Problems in Public Expenditure Analysis*, p. 37.

Under some circumstances, the substitution of shadow prices for actual market prices may be irrelevant to decision-making. For instance, some projects may be "fail safe"; while substituting shadow prices for market prices would serve to increase the desirability of such projects as social investments, the use of market prices alone shows such projects to be allocatively efficient. Equally, the analyst will encounter instances where it is inconceivable that the substitution of shadow prices for actual market prices would make a project's allocative benefits greater than its allocative costs. Finally, where a number of alternative investments are being considered, it may be clear that the dominance of one of the alternatives is unlikely to be altered by the substitution of shadow prices for market prices of inputs and outputs. Common sense indicates that it would be useless to devote resources to shadow pricing exercises in the circumstances we have outlined. As Baldwin has remarked in a similar context,

> "There is no point in going to a lot of trouble to establish a doubtful accuracy for values that do not change a conclusion reached with more easily established, well-reasoned values."[29]

Where analysts decide that the substitution of shadow prices for actual market prices would be ideal in theory but irrelevant to project selection, they are nevertheless obliged to indicate to the decision-maker why this is the case. For instance, a form of reverse sensitivity analysis might be undertaken to indicate what values shadow prices would need to assume to affect a decision; these putative shadow prices could then be compared to shadow prices for similar items actually calculated in past analyses.

Similarly, whenever analysts judge that the measurement of implicit allocative effects of projects is not worth the cost, an explicit assessment should be made in the analysis concerning their importance. Otherwise, failure to assess the importance of these unmeasured effects will result in biased decisions in the allocation of funds to projects.

The social discount rate

The benefits and costs of government expenditures may be realized over different time periods, and such differences in time affect evaluations of the desirability of projects. Society is not indifferent between benefits of a public project which are realized immediately and benefits which are realized in some future year. The latter benefits are less valuable because they are not available for immediate consumption or reinvestment. Accordingly, to allow for these welfare costs attributable to the passage of time, discount rates have to be used to convert both benefits and costs into present values in evaluations of public projects. More precisely, costs and benefits occurring in future years are multiplied by a discount factor, $\frac{1}{(1+i)^j}$ where i is the social discount rate per year and j is the index of the year in which the cost or benefit will occur. As j becomes larger, that is, the more remote in the future benefits and costs are, the smaller is the discount factor and hence the present value of costs and benefits. Similarly, the larger the social discount rate, i, the smaller is the present value of costs and benefits occurring in any future year.

Two different bases have been suggested for calculating the social discount rate: the social opportunity cost rate and the social time preference rate, which is lower. Proponents of the former approach argue that resources will be wasted if the discount rate used in evaluating public expenditures is less than the marginal return these funds would yield if invested in the private sector of the economy. Proponents of the social time preference approach usually argue that individuals are prepared to lend money to the government at a much lower rate than the returns obtained by private entrepreneurs, and that the former rate of interest expresses society's views as to the optimal allocation of resources between the present and the future.

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[29] George B. Baldwin, "A Layman's Guide to Little/Mirrlees", *Finance and Development Quarterly*, 9 (March, 1972), p. 21.

Major institutional changes would be required to bring about equality between the rate of return on funds invested by private entrepreneurs and the rate of social time preference.[30] In the absence of such changes, it is theoretically possible to find a second-best social discount rate which is somewhere between the opportunity cost rate and the social time preference rate.[31] Much of the recent literature on the social discount rate has in fact attempted to integrate the two concepts. One approach involves selecting a shadow discount rate which incorporates both the opportunity cost and the time preference concepts.[32] Alternatively, some economists have argued that the social rate of time preference should be used as the discount rate while opportunity costs should be accounted for by shadow pricing the project's perceived cost.[33] In both of these approaches, consideration of the source of the funds used to finance a public project, that is the degree to which private consumption and private investment are displaced, forms an integral part of the analysis.

Our discussion leads to the conclusion that there must be some uncertainty in attempts to specify a particular social discount rate at this time. Accordingly, analysts are encouraged to calculate the net present values of benefits and costs for a range of social discount rates. We recommend the use of a social discount rate of 10 per cent, and of 5 and 15 per cent for sensitivity analyses.[34] It should be noted that these are real, as opposed to nominal, discount rates, which implies that prices are held constant. As mentioned previously, all future benefits and costs should be estimated in constant prices, and thus the social discount rate used to obtain net present values of benefits and costs should also be a real and not a nominal rate. Real and nominal interest rates diverge because of expectations of future price changes.

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30 See William J. Baumol, "On the Social Rate of Discount", *American Economic Review* 58 (September, 1968), pp. 788-802.

31 See Dan Usher, "On the Social Rate of Discount: Comment", *American Economic Review* 59 (December, 1969), pp. 925-29.

32 See, for example, Arnold C. Harberger, "On Measuring the Social Opportunity Cost of Public Funds", in *The Discount Rate in Public Investment Evaluation: Conference Proceedings of the Committee on the Economics of Water Resources Development*, Western Agricultural Economics Research Council, Denver, Colo.: December, 1968 (Report No. 17); and Glenn P. Jenkins, "The Measurement of Rates of Return and Taxation from Private Capital in Canada", in *Benefit Cost and Policy Analysis*, 1972, ed. William A. Niskanen *et al.* (Chicago: Aldine, 1973), pp. 211-45.

33 See, for example, Stephen A. Marglin, "The Opportunity Costs of Public Investment", *Quarterly Journal of Economics* 77 (May, 1963), pp. 274-89; and Harry F. Campbell, "The Shadow Rate of Discount versus the Shadow Price in Social Benefit-Cost Analysis", University of British Columbia, Department of Economics, Discussion Paper 73-16 (October, 1973).

34 The basis underlying the choice of these social discount rates can be briefly set out. Jenkins has estimated the weighted social rate of return on capital in Canada during the period 1965-1969 to be approximately 9.5 per cent. He also found that the social rate of return of 15.1 per cent for manufacturing in this period was the highest of any sector in the economy. See "Returns and Taxation from Private Capital in Canada", pp. 225-226. One might accordingly select 10 and 15 per cent as median and upper bounds for our sensitivity analysis. The upper bound figure could be justified by the argument of Mishan that the use of a discount rate reflecting a commercial rate of return on capital will satisfy the decision-maker that "only those public projects having expected returns greater than those of the highest-yielding private investments are accepted". See Mishan, *Cost-Benefit Analysis*, p. 305. A lower bound social discount rate of five per cent might be justified on the basis that Helliwell et al. found this to be approximately the real supply price of capital in Canada in the period 1955-72. See "The Supply Price of Capital in Macroeconomic Models", p. 281.

Investment criteria applicable where the effects of projects can be valued in monetary terms

1. Net present values, benefit-cost ratios, and internal rates of return

Where projects being considered for selection are neither interdependent nor mutually exclusive, and where decision-makers are not restricted in their choice of projects by limitations on funds or other constraints, all projects should be undertaken which have a positive net present value, that is, which have discounted benefits that exceed their discounted costs. Alternative investment criteria which are also valid in these circumstances are that all projects should be undertaken which have benefit-cost ratios exceeding unity, or have internal rates of return which are greater than the social discount rate. To explain the derivation and relationship between these various criteria, let

$b_0, b_1, b_2, \ldots b_n$ = project benefits in years 0, 1, 2 . . . n

$c_0, c_1, c_2, \ldots c_n$ = project costs in years 0, 1, 2 . . . n

i = social discount rate
r = internal rate of return

As indicated earlier, the present value of costs and benefits of a project in any year are obtained by multiplying each prospective cost or benefit by a discount factor $\frac{1}{(1+i)^j}$ where j is the index of the year concerned. The discounted values of costs and benefits in all years are then summed to yield total present values of costs and benefits as follows:

Present value of benefits:

$$\sum_{j=0}^{n} \frac{b_j}{(1+i)^j} = \frac{b_0}{(1+i)^0} + \frac{b_1}{(1+i)^1} + \ldots + \frac{b_n}{(1+i)^n}$$

Present value of costs:

$$\sum_{j=0}^{n} \frac{c_j}{(1+i)^j} = \frac{c_0}{(1+i)^0} + \frac{c_1}{(1+i)^1} + \ldots + \frac{c_n}{(1+i)^n}$$

The net present value of a project is thus:

$$\sum_{j=0}^{n} \frac{b_j}{(1+i)^j} - \sum_{j=0}^{n} \frac{c_j}{(1+i)^j} = \sum_{j=0}^{n} \frac{(b_j - c_j)}{(1+i)^j} = \frac{(b_0 - c_0)}{(1+i)^0} + \ldots + \frac{(b_n - c_n)}{(1+i)^n}$$

Our first investment criterion states that projects will be undertaken only if their net present values are positive.

Correspondingly, the benefit-cost ratio for a project is:

$$\frac{\sum_{j=0}^{n} \frac{b_j}{(1+i)^j}}{\sum_{j=0}^{n} \frac{c_j}{(1+i)^j}}$$

Using the benefit-cost ratio as an investment criterion, all projects will be undertaken which have benefit-cost ratios greater than unity.

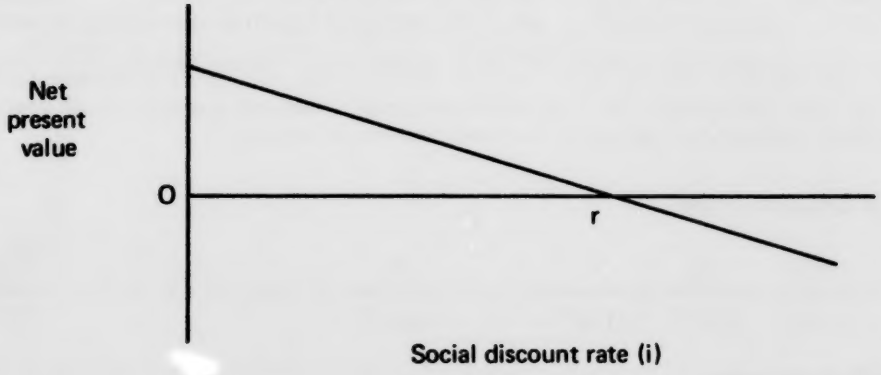
The internal rate of return (r) is that rate of interest which equates the present value of benefits and costs. In other words, r is the rate of interest for which:

$$\sum_{j=0}^{n} \frac{b_j}{(1+r)^j} - \sum_{j=0}^{n} \frac{c_j}{(1+r)^j} = 0$$

The relationship between the net present value of a project, the social discount rate (i) and the internal rate of return (r) is illustrated in Diagram 3.

Diagram 3

Net present values, social discount rates and internal rates of return



The diagram shows that for social discount rates below r, the present value of project benefits exceeds the present value of project costs (the net present value of the project is positive). At social discount rates greater than r, the net present value of the project is negative (the present value of costs exceeds the present value of benefits). Using the internal rate of return, our investment criterion is that only those projects will be undertaken where $r > i$.

2. Problems in estimating and using the various investment criteria

There are practical problems in estimating and using internal rates of return and benefit-cost ratios. For instance, difficulties arise in comparing the benefit-cost ratios of projects where analysts adopt different methods of classifying the unfavourable side-effects of projects. Earlier, we defined the benefits of projects as consisting of all those favourable effects which increase production or consumption opportunities and the costs of projects as consisting of all those unfavourable effects which decrease production or consumption opportunities. In contrast, some analysts prefer to treat unfavourable side-effects of projects as disbenefits, and subtract them from project benefits in assessing whether projects should be undertaken or not. The underlying rationale for the latter procedure is that it is preferable to distinguish all project outputs (favourable or unfavourable) from all project inputs.

This difference in treatment of disbenefits can lead to the anomaly of two different benefit-cost ratios being applicable to the same project. For example, let us suppose it is estimated that noise associated with operation of a proposed small local airport will lower some adjacent

property values by $200,000, and the analyst is uncertain as to how to classify this effect.[35] Otherwise, the present values of benefits and costs of the airport are respectively estimated as being $800,000 and $200,000. If the analyst subtracts the reduction in land values from other airport benefits, the benefit-cost ratio for the facility is three. Conversely, if the reduction in land values is treated as a cost, the benefit-cost ratio for the project becomes two. Inconsistency in the classification of such side-effects of projects prevents the benefit-cost ratio from being useful in choosing among alternative public expenditures. Estimates of the net present values and internal rates of return of projects are not subject to similar ambiguities.

There are also difficulties in using the internal rate of return as an investment criterion when the internal rate of return for a project is not unique. This problem can arise when there is more than one sign change in the net benefit stream for a project. Since investment costs are mostly concentrated in the first years of a project's life, the net benefit stream in these years will usually be negative. Subsequently, when the project is in operation, its net benefit stream usually becomes positive as current benefits exceed current operating costs. However, the time-stream of project benefits may again become negative if, for instance, large replacement costs are required for capital equipment at fixed intervals. In such instances of more than one sign change in a project's net benefit stream over time, multiple solutions may occur in calculations of the project's internal rate of return.[36] In such circumstances, there are obvious difficulties in using the internal rate of return as an investment criterion. Where the social discount rate is specified, calculation of neither the net present value nor benefit-cost ratio of a project is subject to similar indeterminacy.

Besides these difficulties which arise in calculating benefit-cost ratios and internal rates of return, instances may also arise when these measures conflict with the calculation of net present values as criteria for ranking projects according to desirability. To pursue our earlier local airport example, let us say that facilities can be provided at two scales. The first has a present value of benefits of $800,000, a present value of costs of $400,000 and thus a net present value of $400,000 and a benefit-cost ratio of two. Suppose a larger airport might be built by providing extra runways for additional benefits and costs whose present values are $200,000 and $100,000 respectively. Using calculations of net present values as our investment criterion we would proceed to build the larger airport, since its net present value is greater by $100,000. However, using the benefit-cost ratio as our investment criterion, we would be indifferent between the two airport scales, since the benefit-cost ratio is two in both cases.

The internal rate of return and net present value of projects can also be conflicting guides to the relative desirability of projects. Diagram 4 and the accompanying Table 1 illustrate such a conflict. Both projects A and B cost $10,250, which cost is incurred in the initial year of life of the projects. In the following years, Project A has an undiscounted annual benefit flow of $13,500, $2,000 and $500; and Project B has an undiscounted annual benefit flow of $500, $3,000 and $14,000. The diagram and table show the net present values of the projects for different interest or social discount rates. The internal rate of return for each project is, of course, that interest rate at which its net present value is zero.

As indicated in Table 1, Project A has a higher internal rate of return than Project B (43.7 per cent as opposed to 21.5 per cent), but both projects have equal net present values at an interest rate of 5.8 per cent. Thus, while using internal rates of return as our investment criterion would lead us

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[35] Referring to our earlier discussion of allocative and secondary benefits, the decrease in land values due to the noise factor reflects a real decrease in consumption opportunities. It represents neither double-counting for costs incurred elsewhere in the project, nor a pecuniary effect which is offset by a rise in land values elsewhere. Therefore, it should be taken into account in estimating the allocative benefits and costs of the airport.

[36] In fact, there may be as many positive internal rates of return as there are sign changes in the net benefit stream of a project.

to prefer Project A over Project B, use of net present values leads us to different rankings of the desirability of the projects, depending on the rate of interest which is relevant. We are indifferent about choosing between the projects when the interest rate is 5.8 per cent, we prefer Project A when the interest rate is greater than 5.8 per cent, and we prefer Project B when the interest rate is less than 5.8 per cent.

Diagram 4

Conflicts between the internal rate of return and net present value as investment criteria

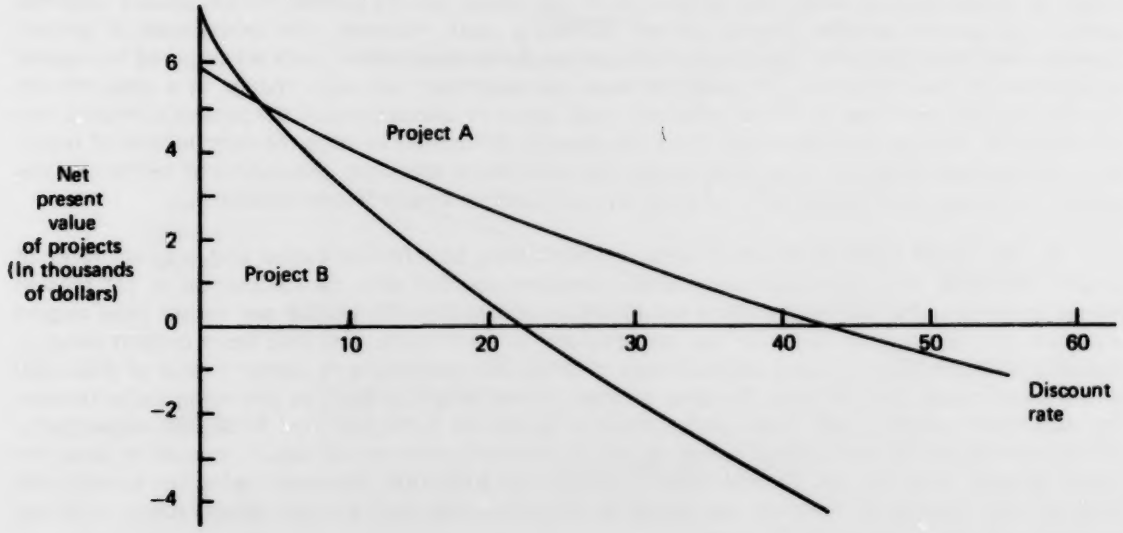

TABLE 1

Interest rates and net present values for two projects, A and B

Interest rate	Net present value (in dollars)	
	A	B
0	5,750	7,250
5	4,853	5,037.1
5.8	4,723.5	4,723.5
12	3,760.7	2,596.4
21.5	2,495	0
43.7	0	−4,144.3

3. The relevant investment criterion for choosing among projects

Where the analyst has to choose among projects, their internal rates of return, benefit-cost ratios and net present values may therefore constitute conflicting criteria for investment. The necessity for choice among projects may arise where a budget constraint exists, so that only the project or projects may be undertaken which do not violate this budget constraint. Alternatively, some projects may be mutually exclusive. Thus, publicly owned land may be able to be used for only one purpose, such as where national park authorities have a choice between developing a recreational site as a wilderness area or for more intensive recreational uses complete with camping grounds, beach facilities, and food concessions. The selection of the optimal size of a project also involves a choice among mutually exclusive alternatives, as for instance where the construction of a two-lane or four-lane highway is being contemplated over a particular route. Since practically any worthwhile benefit-cost analysis involves consideration of mutually exclusive alternatives such as those indicated, it can be seen that the question of the correct investment criterion is one of immediate concern to every analyst.

The fundamental criterion for investment in circumstances of choice is unambiguous: the investment(s) should be chosen which maximizes net present value. We shall first illustrate this point by considering the simple case where the analyst has to choose between two projects, either because of a budget constraint or because the projects are mutually exclusive. The principle will then be extended to more difficult problems of project selection.[37]

4. Selecting one project from two mutually exclusive projects

The rule that we should choose from among competing investment opportunities that project which has the highest net present value amounts to saying that we should choose the project which contributes most to the welfare of society. The essential problem with the use of both the internal rate of return and benefit-cost ratio as investment criteria is that they do not contain as much information about this social profitability of competing projects as is given in calculations of their net present values.

The inadequacy of the rate of return as an investment criterion for choosing between competing projects is perhaps most obvious where the projects compared have different scales. A small project may well have a greater rate of return than a larger project,[38] but we would still prefer the latter if it yields a greater change in net present value.

Even where investments are of the same scale, however, the example illustrated in Diagram 4 revealed that internal rates of return may not indicate that project which, among competing investments, contributes most to net present value. The problem illustrated in Diagram 4 was that the internal rate of return does not take account of the cost of capital, and so may not indicate which project represents the most profitable investment at any given point in time.

Nor does the benefit-cost ratio convey enough information to indicate which project among competing investments is the most socially worthwhile. The benefit-cost ratio is, after all, only a ratio, and ignores the relative sizes of competing projects. Thus, even if Projects A and B have

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37 For a more extensive treatment of this subject, see Harold Bierman and Seymour Smidt, *The Capital Budgeting Decision* (New York: MacMillan Co., 1975). Bierman and Smidt indicate that, in some circumstances, decision rules can be formulated so that internal rates of return yield the same investment criteria as net present values. However, little would appear to be gained by internal rates of return calculations, since net present values can be calculated easily and lead directly to the correct ranking of projects.

38 In fact, the theoretical concept of the marginal efficiency of capital leads us to expect that to invest more, we must accept a lower rate of return. The unfortunate fact is that investment opportunities with high rates of return are limited in availability.

benefit-cost ratios of 2.0 and 1.25 respectively, Project A will have a lower net present value if the present value of its benefits is $1,000 and the present value of Project B's benefits is anything greater than $2,500. If Projects A and B are mutually exclusive, or if a budget constraint forces us to choose between them, we would therefore prefer to invest in Project B.

5. More complex problems of project choice

The principle of maximizing net present value of investments also applies to more complicated problems of project choice, but the problem of project selection is no longer amenable to simple decision rules.

Thus, the analyst may be called upon to advise decision-makers on the selection of a list of projects where budget constraints limit the number of projects that can be undertaken. The budget constraints may apply not only to the current fiscal year, but also to future years in which project costs will be incurred. It is worth noting that such budget constraints imply that there is a premium price on available capital over and above the price reflected in the social discount rate. In effect, an adjusted net present value which reflects this premium price on capital has to be calculated for each project eligible for selection. Only those projects which have a positive adjusted net present value will be undertaken.

Again, the list of projects which are candidates for selection may contain groups of projects which are mutually exclusive; the obvious restriction on choice is that only one project can be chosen from each of the mutually exclusive sets.

Nor may project interdependence be limited to mutually exclusive investments. Mutually exclusive projects are substitute projects, but the benefits and costs of undertaking a project may also depend upon the construction of complementary investments. Such complementarity is very market in many water resource investments; as, for instance, when the construction of a hydroelectric plant makes possible irrigation and recreation facilities. Here, investment in one type of facility may have to be treated as contingent upon the acceptance of complementary projects. Alternatively, where complementarities among projects are marked, it may be preferable to treat the investment decision as relating to the entire system of such projects, rather than to each of the component parts considered separately.

Indivisibilities or lumpiness in projects may also pose problems in project selection, in that large projects may not be able to be undertaken partially or in fractions in order to meet a budget constraint on the total amount of investment that can be undertaken.

Where such limitations on choice among a number of projects exist, the capital budgeting decision reduces to a problem of constrained maximization: standard programming techniques may be used to look at all combinations of projects and to select that set or package which satisfies the specified constraints on choice and has the greatest net present value.[39]

Non-efficiency effects

Introduction

The federal government may have goals in undertaking public projects other than that of improving efficiency in the economy. It may be interested in the effects of projects on the distribution of income, either among Canadians generally, or among regions of Canada. It may be interested in the effects of projects on the quality of environment, or on the country's defence capacity. These and other non-efficiency effects may be critical for choosing among alternative public projects, but

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[39] See, for instance, H. Martin Weingartner, *Mathematical Programming and the Analysis of Capital Budgeting Problems* (Englewood Cliffs, N.J.: Prentice-Hall, 1962).

a problem arises in comparing them with efficiency effects. Whereas our stated objective in analyzing the efficiency effects of public projects was to compare estimates of costs and benefits as much as possible in the common measuring unit of dollars, attainment of non-efficiency objectives cannot be expressed in the same dollar terms. This section of the *Guide* will describe some of the more important incommensurate effects and suggest methods of dealing with them in benefit-cost analysis.

The problems posed by incommensurate social objectives are as ancient as economics itself, and as topical as the daily newspaper. Adam Smith's approval in 1776 of the British Navigation Acts on the grounds that "defence . . . is of much more importance than opulence" is a well-known illustration of the kind of policy dilemma they lead to.[40] Today, a primary concern of administrations around the world is the alleged trade-off between the policy goals of high levels of employment and price stability. Again, a federal government may have to incur some sacrifice in national output in order to reduce regional income disparities by altering the pattern of location of industry. The problem of incommensurability in policy objectives thus arises in its most intractable form when, in order to attain one social good, one has to make sacrifices in attainment of another. One cannot attach a price which has any universal validity to such trade-offs because the degree of attainment of the separate goals will be valued differently by various decision-makers and perhaps will also be valued differently by the same decision-makers in different circumstances. Above all, it should be clear that the analyst cannot select the respective levels of goal attainment society desires in such trade-off situations.

The term "incommensurate objectives" should not be taken to mean that such trade-offs cannot be measured. The analyst's role is to reveal and clarify problems of trade-offs between incommensurate objectives and to try to obtain indicators of the extent to which alternative expenditure projects attain the various incommensurate objectives. Such information will then enable decision-makers to make the required trade-offs in the selection of projects.

It should be emphasized that some of the major problems posed by incommensurate objectives in economics fall outside the domain of benefit-cost analysis. As we have stressed before, benefit-cost analysis is a form of partial equilibrium analysis, and its use is only legitimate where prices, other than those pertaining to the project under consideration, can reasonably be assumed to be constant. Accordingly, trade-offs at the macroeconomic level (such as the supposed conflict between high levels of employment and price stability) fall outside the area of concern of benefit-cost analysis.

This is not the place for an exhaustive list of goals of government which are incommensurate with efficiency but may be important criteria for choice among alternative projects. Indeed, there might be little point in giving such a list, since over time some goals become obsolete as circumstances change,[41] and some goals become prominent as public attention shifts to new areas of concern. Nor will some goals of current public concern be relevant in examination of all public expenditure proposals. For example, concerns for the quality of the environment and national defence may well be irrelevant in consideration of alternative public health programs.

Nevertheless, two important types of incommensurate effects will be closely examined. In the first place, we will see that problems posed by incommensurate effects are integral even to the calculations of the efficiency of alternative projects, insofar as uncertainty attaches to estimates of costs and benefits. Secondly, we will see that there are sound reasons for outlining to the decision-maker the effects of projects on the distribution of income.

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40 *An Inquiry into the Nature and Causes of the Wealth of Nations*, ed. Edwin Cannan (London: Methuen, 1904), p. 429. The Navigation Acts had the effects of restricting trade but promoting the size of the British merchant marine.

41 Thus, a concern for the effect of government expenditures on the balance of payments is of less importance under our current floating exchange rate regime than under a fixed exchange rate regime.

The basic prerequisite in dealing with any kind of incommensurate effect in analyses of alternative projects is that full descriptions of such effects be presented to the decision-maker. Our subsections on uncertainty and the income distributional effects of projects will accordingly outline useful ways in which the analyst can present such information.

The treatment of uncertainty

1. Types of uncertainty

In our exposition of the efficiency effects of projects up to this point, the estimates of future costs and benefits that we have been considering might be termed expected outcomes. No account has been taken of the effects of uncertainty in calculating project outcomes. It needs to be realized that the incorporation of information on uncertainty can significantly affect the attitudes of decision-makers towards alternative courses of action considered in a benefit-cost analysis. The pervasiveness of the problem of uncertainty, and the various forms it assumes, can be illustrated in a simple example.

Suppose we are trying to value the recreational benefits to be provided by a proposed public park. In the initial year of operation of the park, we might value its recreational benefits by multiplying expected attendance by the costs of going to the park. Expected recreational benefits in subsequent years of operation might then be estimated on the basis of our projections for the initial year, with allowances being made for factors such as population growth. What might such average estimates conceal?

There are some elements of randomness even in events which are completely understood. For instance, attendance at our park will obviously depend on such factors as annual rainfall and snowfall. The problem is that one can never predict the exact amount of precipitation for a particular year. However, past meteorological records will enable us to predict the expected or mean value of these variables with an associated standard error. The type of uncertainty involved here, the element of chance in random events, is often referred to as statistical uncertainty. Thus, the first-year benefits may be a poor basis for prediction of future benefits, due to various forms of statistical uncertainty.

The term "environmental uncertainty" encompasses many types of uncertainty which are often distinguished in benefit-cost analyses. Every forecast has to assume that a specific environment will prevail in the future, and environmental uncertainty arises when there is uncertainty associated with the factors given. Uncertainty arising from technological change is a case in point. For instance, the task of predicting winter recreational usage of the park in our example is substantially different today from what it would have been before the development of the snowmobile. Potential legal changes are another type of environmental uncertainty: winter recreational usage of the park in our example would again be substantially different if the legislature were subsequently to prohibit the use of snowmobiles in public parks. Environmental uncertainty could be regarded as a form of statistical uncertainty, but it is often useful to separate it as a special problem.

A type of environmental uncertainty which deserves particular attention in benefit-cost analyses arises from the potential reactions of other decision-making units to alternative courses of action under consideration. For instance, attendance at the park in our example might be increased substantially if, as a result of the decision to create the park, complementary recreation facilities were developed in nearby towns, or other governmental authorities decided to improve the road system in the vicinity of the park. The reactions to alternative courses of action by other decision-makers, whether households, other levels of government, business or labour, are clearly key factors in a benefit-cost analysis of alternative projects.

2. The problem of uncertainty in benefit-cost analysis

The problem posed by uncertainty in benefit-cost analysis is simple and clear-cut. Our objective in such analyses is to employ estimates of costs and benefits in money terms as far as possible. The problem is that the effects of uncertainty cannot be estimated in money terms for the simple reason that one cannot attach to different degrees of uncertainty a single price which has general acceptability. This problem, of course, exists for many costs and benefits which must be evaluated.

To illustrate the problem, let us suppose the decision-maker has to choose between two mutually exclusive projects which have the probability distribution of outcomes given in Table 2. It is appropriate at this point to introduce the concept of the expected value of an event, which is the analogue in probability analysis of an arithmetic mean. The expected value of each project in Table 2 is simply the value of each of its possible outcomes times the probability of the outcome taking place, summed over all possible outcomes.

TABLE 2

Expected Values of Project Decisions

	Possible payoff from a particular project (in dollars)	Probability	Expected payoff from project (in dollars)
Project A:	– 50,000	.1	– 5,000
	0	.2	0
	100,000	.5	50,000
	200,000	.2	40,000
	Expected value of the decision		85,000
Project B:	–150,000	.4	– 60,000
	– 50,000	.1	– 5,000
	200,000	.2	40,000
	500,000	.3	150,000
	Expected value of the decision		125,000

Table 2 shows that Project A has a lower expected value than Project B, but that the possible outcomes in Project A are clustered more closely around the expected value. A graph of the probability distribution for Project A would be narrow in range and sharply peaked. In contrast, Project B has a relatively broad range of possible outcomes and the distribution of outcomes is skewed. There is a 50 per cent probability of substantial losses in Project B, but the probabilities of high returns occurring in the project are sufficient to make its expected value positive.

Faced with a choice between Project A and B, some decision-makers would be risk-averters. They would prefer to hedge against uncertainty by selecting Project A with its more certain return rather than Project B with its higher expected return but with its possible outcomes ranging from large losses to fantastic gains. Other decision-makers might be risk-takers, choosing Project B over Project A in the same circumstances.

It is also worth noting that attitudes towards uncertainty may depend not only upon the decision-maker, but upon the circumstances. Indeed, the same decision-maker may make both risk-averting and risk-taking choices in different situations. After all, those who gamble in buying Olympic lottery tickets may also hedge against loss of life and property by taking out insurance.

We can therefore conclude that there is no universal price for uncertainty because attitudes to risk vary with decision-makers and circumstances. It is perhaps superfluous to add that the responsibility for pricing uncertainty therefore rests with the decision-maker, and not the analyst.

Our example also shows the necessity for presenting decision-makers with more information on uncertainty than single-valued estimates of possible events, such as the expected value of a project. Single-valued estimates can be a misleading criterion for project choice because they conceal information on the variance of possible project outcomes, and thus on the risks accompanying the various choices.

3. Methods of dealing with uncertainty

Our general advice to the analyst as to how to treat uncertainty is therefore the same as that of McKean, namely, to avoid concealment and to present quantitative indicators of its importance whenever possible.[42] In some circumstances, the analyst may be able to derive probability distributions of uncertain outcomes from past events, as in the previous example of a benefit-cost analysis of a proposed park, where the probabilities of receiving different amounts of snowfall in a given year could be estimated from meteorological records. In other circumstances, the best quantitative indicators available may simply be subjective probability estimates derived from the best guesses of experts.

Regardless of the source of information, however, there are some circumstances in which the analyst's job is completed when the relevant information has been assembled and presented to the decision-maker. Thus, where the viability of a single project or the relative rankings of alternative projects are affected by considerations of uncertainty, the task of pricing uncertainty is clearly the preserve of the decision-maker.

There are other circumstances, however, in which the analyst can lighten the load of the decision-maker by pointing out that further attention to the problems created by uncertainty is irrelevant to a decision. It may be, for instance, that a project is "fail-safe" or "fail-sure" in that major foreseeable contingencies may not alter a decision that a project should be accepted or rejected. Or, where alternative courses of action are being considered, examination of uncertainty may reveal one course of action to be dominant, that is, the best in all relevant circumstances. A quick search for dominance by the analyst is clearly a time-saving procedure. We will next consider a short-cut method, called sensitivity analysis, of establishing whether this desirable characteristic is present in an investment decision.

3a. Sensitivity analysis

In circumstances where firm probabilities cannot be attached to the future value of parameters which are likely to affect the outcome of a benefit-cost study, sensitivity analysis may represent the only method of describing quantitatively uncertain outcomes to decision-makers. In this simple technique, different values for uncertain variables are used to construct alternative scenarios of outcomes for presentation to the decision-maker.

It has already been suggested that the analyst should carry out such sensitivity analyses where questions arise as to the magnitude of the social discount rate, future price ratios and shadow prices for unemployed resources, but the technique is generally valuable in dealing with any type of environmental or technological uncertainty. For instance, consider the example of the benefit-cost analysis of the proposed park previously mentioned in outlining various types of uncertainty. Suppose the analyst does not know whether or not the legislature will prohibit operation of snowmobiles in public parks. In analyzing the benefits of the proposed park, the analyst might therefore simply prepare two scenarios showing projected park usage with and without a ban on snowmobiles.

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[42] McKean, *Efficiency in Government Through Systems Analysis*, p. 64.

Sensitivity analysis may be a useful first step in tackling problems created by uncertainty in benefit-cost analyses even where probabilities can be attached to outcomes. In the latter circumstances, sensitivity analysis has the merit of allowing economy of effort in analysis. Thus, the choice of polar values for parameters can be used in some cases to establish quickly whether there is a dominant course of action among several alternatives or whether an individual project is fail-safe or fail-sure. Where such dominant fail-safe or fail-sure options are evident, further attention to problems of uncertainty becomes necessary. Moreover, even where sensitivity analysis reveals that foreseeable uncertainties may affect the viability of a single project or the ranking of alternative projects, the technique may still be useful in revealing those parameters in the analysis with respect to which a decision is most sensitive. Other techniques may then be used to examine more closely the problem of uncertainty in these sensitive parameters.

The more explicit techniques for incorporating information on uncertainty directly into benefit-cost calculations will be examined next. We will first consider short-cut techniques of dubious validity, such as using higher social discount rates or artifically limiting the economic lives of projects. Problems with the use of point estimates of probability will then be examined. Finally, some more extensive techniques, such as Monte-Carlo simulation methods and decision-trees, will be discussed briefly.

3b. Short-cut methods of allowing for uncertainty: premiums in the social discount rate and artificial limits to the lives of projects

Short-cut methods of incorporating uncertainty into benefit-cost analyses are occasionally encountered. For instance, some analysts use discount rates for this purpose, as well as to express the social opportunity cost of capital or social time preference. The rationale underlying this procedure is that forecasts of the benefits and costs of a project become more speculative the longer the time horizon or project life considered. Adding a premium to the discount rate reduces the importance in the analysis of data forecasted for the remote future. This procedure may also be justified on the ground that, in the private sector of the economy, higher rates of return are needed to attract capital into risky investments.

This practice of using the discount rate to allow for uncertainty in project evaluation has limited validity. In effect, it implies that uncertainty compounds itself at a fixed rate over time. This is unlikely to be the case. Where different degrees of uncertainty can be ascribed to future values of variables, it is preferable to let estimates of future annual benefits and costs reflect these different degrees of uncertainty, and to aggregate present values using a riskless discount rate.

A second rough-and-ready method of allowing for uncertainty in benefit-cost calculations is to impose an artificial limit on the life of a project. Thus, if the benefits from a project are expected to continue for 20 years or so, it may be stipulated that the project must meet some specified investment criterion within five or 10 years, depending upon the degree of uncertainty which it is assumed will prevail in the future. The arbitrariness in selection of the length of such cut-off periods should be evident. It should also be noted that the procedure is superfluous where long cut-off periods are used in conjunction with any sizeable discount rate.[43]

3c. Collapsing the distribution of possible outcomes into several numbers

We have already seen that a single-valued estimate of an uncertain outcome, such as the expected value of a project, constitutes insufficient information for a decision-maker, because data on possible variance in project outcomes is concealed.

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[43] Thus, cut-off periods of 50 years are often used in analyses of water-resource projects, although the physical life of a dam may be a matter of centuries. Yet at a discount rate of 10 per cent, a net benefit of $118 in 50 years time has a present value of only about $1.00.

Often one finds such single-valued "best estimates" augmented by "most optimistic" and "most pessimistic" projections of likely outcomes. Such calculations give the decision-maker an idea of the range of possible project outcomes, but again do not reveal the probabilities attached to the "most likely", "most optimistic" or "most pessimistic" forecasts.

The problems with these various forms of point estimates can be illustrated with the aid of the example outlined in Table 3 below. The table contains a series of annual estimates of the net benefits from a project (or the net present value of benefits minus the net present value of costs), and the probabilities attached to these various annual net benefit streams. It is assumed that each of the probabilities associated with these annual net benefit streams is independent of the annual net benefits achieved in earlier periods. In Table 3, this implies that there is a 50 per cent probability of achieving a net benefit of 9 in the second period, regardless of whether the Period 1 net benefits were five or 10. The problem of dealing with uncertainty when probabilities are dependent is much more difficult, requiring more complicated techniques. It will be briefly discussed after the independent case.

TABLE 3

Probabilities of net benefits from a project

Period 1		Period 2		Period 3		Period 4	
NB*	Prob.**	NB	Prob.	NB	Prob.	NB	Prob.
5	.2	3	.3	5	.4	3	.1
10	.6	9	.5	9	.5	8	.6
20	.2	12	.2	13	.1	11	.3

* NB – net benefits
** Prob. – probability of occurring

As can be seen from the table, the most likely estimate of total net benefits accruing in the four-year period considered, or the sum of the most likely net benefits in each year, is 36. Similarly, the most optimistic and least optimistic projections of total net benefits from the project are 56 and 16 respectively. To find the total probability of each of these projections occurring, we have to find the product of the probabilities for each component of the outcome in each period. Thus, the most likely estimate has only a .09 chance of occurring (.6 x .5 x .5 x .6 = .09). Similarly, the most optimistic and least optimistic outcomes have total probabilities of only .0012 and .0024 respectively of occurring. Faced with these probabilities, the decision-maker might well like to know more about the chances of other outcomes occurring and, indeed, to have a picture of the total probability distribution of outcomes.

3d. Direct and simulated calculations of probability distributions of outcomes when events are independent

Direct calculation of probability distribution of outcomes requires specification of the probability distributions of variables affecting the outcomes, and the interrelationships between these distributions, as in Table 3. The probability distribution for the example illustrated in Table 3 might be most economically worked out by hand. Since there are only three net benefit figures for each year in the four-year period, there are a total of 3^4 or 81 possible outcomes when the various combinations of probabilities are considered. However, it can be seen that it becomes rather impractical to work out probability distributions of outcomes by hand when larger total combinations of probabilities are involved. For instance, if the project life for the example in Table 3 were quintupled to 20 years, and three estimates of net benefits were made for each year of project life, there would be a total of 3^{20} or nearly 3 1/2 million possible benefit streams for the project. In such circumstances, what is required is a sample of what possible outcomes might be.

Computer simulation methods can be used to generate a manageable synthetic sample of such outcomes. The probability distribution of values for each variable affecting the outcome (for example, each year's benefits in Table 3) is first specified. A value for each of the underlying variables affecting the total outcome is then selected at random. The sum of the randomly selected values for variables affecting the outcome is then obtained. This process of assigning random values to variables affecting the outcome and calculation of the outcome is then simply repeated many times to build up a probability distribution of outcomes. This computation process, often termed the Monte Carlo technique, is concluded when further calculations no longer affect the relative frequency of outcomes.

Having calculated the total distribution of outcomes by hand or having simulated this distribution by the use of computers, the analyst can then summarize the implications of the distribution for the decision-maker by computing the usual estimates of central tendency and dispersion such as the mean and the standard deviation or variance.

3e. Dependent decision-making involving uncertainty

Decision involving uncertainty in a project may be sequential in time and executed in stages, the decision-maker having options open at some stage of a project which are closed off by taking a particular course of action. One method which has been developed to deal with this problem is that of using "decision-trees". Briefly stated, decision-trees aid the decision-maker by revealing the time sequence of points in a project at which decisions have to be taken, the options or strategies available at the decision points, the uncertainties associated with particular courses of action, and the costs of alternative courses of action foreclosed by the choice of a particular option.[44] Due to their complexity, decision-trees are used infrequently in benefit-cost analysis. They are unwarranted in cases where the range of outcomes is independent of previous decisions or previous outcomes. In cases where the relationship between each year's outcomes is unclear, the burden of proof must rest on showing that the independence assumption is inappropriate.

The distribution of income

The question of what treatment should be accorded to distributional effects in benefit-cost analyses has been the subject of some controversy. The range of opinions on this issue extends from the position that such information should not be included in benefit-cost analyses[45] to the position that efficiency and distributional effects can be made fully commensurate and should be integrated in a measure of "grand efficiency".[46] The basis for these theoretical positions will be examined next. We will also indicate whether the distributional effects of projects require any different treatment from that advocated previously for other project effects incommensurate with efficiency, namely description and quantification wherever possible to facilitate evaluation by the decision-maker.

1. The theoretical basis for benefit-cost analysis

An examination of the criterion for efficiency underlying benefit-cost analysis reveals good reasons why analysts should be interested in ascertaining the effects of projects on the distribution

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[44] For an excellent treatment of dependent decision-making involving uncertainty and the decision-tree method, the reader is referred to Howard Raiffa, *Decision Analysis* (Boston: Addison Wesley, 1968).

[45] For a recent restatement of this position, see Arnold C. Harberger, "Three Basic Postulates for Applied Welfare Economics: An Interpretive Essay", *Journal of Economic Literature* IX (Sept., 1971), pp. 785-97.

[46] See Burton A. Weisbrod, "Income Redistribution Effects and Benefit-Cost Analysis", in *Problems in Public Expenditure Analysis*, pp. 177-209.

of income.[47] As we have seen, the change in efficiency associated with a project is simply obtained by comparing the allocative benefits of the project with its allocative costs. If the allocative benefits associated with the project exceed the allocative costs, it is considered that the project is efficient and should be undertaken.

This criterion of efficiency is also referred to in welfare economics as a test for potential Pareto improvements: the latter being defined as any economic change whose benefits could be distributed so as to make everyone better off. It should be noted that the test for potential Pareto improvements does not require that gainers have to compensate losers; the mere fact that compensation would be successful is considered as the criterion that the project should be undertaken.[48]

The potential Pareto improvement criterion thus involves several strong implications about welfare and the relation between welfare and the distribution of income that are not usually accepted. Interpersonal comparisons of welfare, such as are made in the test, are usually avoided by economists. Moreover, by adding income changes without taking into account the income levels of gainers and losers, the test involves the assumption that the marginal utility of income is equal for all persons, that is, that an extra dollar of income has the same value for a rich person as a poor person. Most economists – and others – would reject this assumption. Finally, it can be shown that the test favours the status quo. The allocative benefits and costs which result from a government project are a function of the existing distribution of income, because this distribution of income affects the demands of consumers and the supply of inputs by resource owners. Other initial distributions of income would hence entail other patterns of production and consumption, and different efficient allocations of resources in the economy.[49]

Our examination of the welfare economics underlying the criterion for efficiency in benefit-cost analysis thus reveals that this criterion is not neutral or value-free with respect to effects of projects on the distribution of income. Indeed, it has been shown that questions of equity and efficiency cannot be separated theoretically in benefit-cost analysis.

2. Arguments for restricting benefit-cost analysis to efficiency considerations

Some of the arguments in favour of confining benefit-cost analysis to efficiency considerations seem to rest on a misconception of the analyst's role in the policy-making process; such arguments appear to be based on the assumption that the economist is not competent to assign prices to distributional effects.[50] One can agree entirely that the analyst should not attach his own valuations to such effects. It does not follow, however, that equity issues should be ignored in benefit-cost analysis, or that the decision-maker cannot value distributional effects if given the information on which to base a judgment. Indeed, the analyst who avoids measuring or describing non-price effects which may have an important influence upon a decision seems to be ducking his responsibility. Moreover, as we shall see, the measurement of distributional effects by the analyst is not an easy task and may require as much work as measurement of efficiency effects.

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47 For a comprehensive derivation and examination of welfare criteria in benefit-cost analysis, the reader is referred to a paper by Walter Hettich, "Distribution in Benefit-Cost Analysis: A Review of Theoretical Issues", *Public Finance Quarterly*, forthcoming.

48 For those familiar with welfare economics, it can be seen that the test for potential Pareto improvements is thus derived from the test for improvements in welfare associated with Hicks and Kaldor.

49 This is a standard criticism of the Hicks-Kaldor welfare test. See Tibor Scitovsky, "A Note on Welfare Propositions in Economics", and Paul A. Samuelson, "Evaluation of Real National Income", both in *A.E.A. Readings in Welfare Economics*, ed. Kenneth J. Boulding and Tibor Scitovsky (Homewood, Ill.: Irwin, 1969), pp. 390-433.

50 See, for instance, Arnold C. Harberger, "Three Basic Postulates for Applied Welfare Economics: An Interpretive Essay", pp. 785-86.

Musgrave has put forward a different argument for restricting benefit-cost analyses to efficiency considerations, contending that it is preferable for two separate branches of government to concern themselves with the questions of efficiency in public expenditures and the desired distribution of income.[51] Musgrave therefore proposes that all public expenditures be selected on efficiency grounds, with undesired distributional effects being subsequently corrected by means of taxes and transfer payments imposed by the distributional branch of government.

As a theoretical ideal, this argument has considerable merit: it is always easier to attain separate goals by employing as many policy instruments as there are goals. As a practical matter, however, we lack a distributional branch of government, and it may only be possible to capture the intent of Musgrave's model by incorporating data on distributional and efficiency effects in the comparison of alternative public expenditure projects.

Musgrave's argument may also miss the point if, as appears likely, governments are concerned as much with how redistribution of income is attained as with what distribution of income is desired. Thus, for a variety of reasons, ranging from a dislike of transfer payments as being demeaning to their recipients, to the heritage of the Protestant ethic, governments may prefer to redistribute income wherever possible by means of expenditure projects which affect employment and earnings rather than by means of taxes and transfer payments.

A final point with respect to Musgrave's argument that efficiency and equity should be pursued by separate policy instruments is that redistribution of income by means of tax and transfer payments is not a costless procedure in efficiency terms; such taxes and transfers require administrative resources and have adverse effects on incentives to work.[52] Unfortunately, at present we do not know the comparative costs of redistributing income directly through the tax and transfer mechanism or indirectly through other forms of public expenditures. Nevertheless, it is clear that the presence of efficiency costs in direct income redistribution favours joint consideration of efficiency and distributional effects in selection of other public expenditures. Thus, projects which have favourable distributional effects save costs which would otherwise be incurred in direct income redistribution, and projects which have unfavourable distributional effects imply that costs would have to be incurred in tax and transfer programs designed to remedy the resulting distribution of income.

In conclusion, we hope that we have given some sound reasons for estimating distributional effects in benefit-cost analyses of public projects. Regardless of any academic controversy on this subject, governments are likely to continue to demand information on the distributional as well as the efficiency effects of potential public projects, and may consider the former effects to be the more important.[53] The benefit-cost analyst who wishes to be relevant should therefore attempt to include information on the potential distributional consequences of public projects for the consideration of the decision-maker.

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51 See Richard A. Musgrave, "Cost-Benefit Analysis and the Theory of Public Finance", *Journal of Economic Literature* VII (Sept., 1969), pp. 803-04.

52 Theoretically, lump-sum taxes and transfer payments would avoid adverse incentive effects, but such taxes and transfers may be unattainable in practice and undesirable for other reasons even if they could be implemented. See Burton A. Weisbrod, "Collective Action and the Distribution of Income: A Conceptual Approach" in U.S., Congress, Joint Economic Committee, Subcommittee on Economy in Government, *The Analysis and Evaluation of Public Expenditures: The PPB System*, 91st Cong., 1st sess., 1969, pp. 192-93.

53 W.A. Niskanen's conclusions on this issue seem as valid in a Canadian context as in an American context:

> "The implicit assumption of many domestic program analyses is that the objective of public policy is to maximize the income (or the wealth) of the nation . . . In our system, at least, distributional considerations are the essence of politics, and the "national income" model's exclusive focus on allocative conditions often leads to either incorrect decisions or rejection of the analysis."

"Why New Methods of Budgetary Choices? – Administrative Aspects", *Public Finance* 27, No. 2 (1972), pp. 101-102.

3. Proposed integration of efficiency and distributional effects in benefit-cost analysis

Some writers who advocate inclusion of distributional effects in benefit-cost analysis have gone a step beyond merely advising that such effects should be displayed to facilitate valuation by the decision-maker. These writers have attempted to make efficiency and distributional effects commensurate by weighting benefits and costs according to the income levels of persons affected. Much of the hard-core theoretical opposition to inclusion of distributional considerations in benefit-cost analysis probably rests on a fear of this procedure, for what is in effect being proposed is the pricing of distributional effects. The attempts to derive such weighting functions will now be examined.

Some of the attempts to integrate efficiency and distributional effects have been based on strong theoretical presumptions, such as the existence of a social welfare function, or consensus in society on the value which should be attached to a marginal dollar's worth of income to persons in different income classes. It has been proposed that this social marginal utility of income to persons in different income classes can be inferred from past policy actions, and the results used to construct weights for distributional effects in benefit-cost analyses of proposed projects. Thus, Haveman has argued that marginal income tax rates for people at different income levels reflect legislators' perceptions as to the social marginal utility of income, and has derived distributional weights on the basis of this assumption.[54]

Weisbrod has suggested that information from past expenditure decisions can be used to derive distributional weights.[55] Briefly, the procedure he suggests involves looking at projects which were approved although they were less efficient than projects which were ultimately rejected. Assuming that the former projects must have been accepted because of their distributional consequences, decision-makers were implicitly assigning a price to distributional effects. Given enough project data of this kind, one can determine the particular distributional weights held by legislators. Weisbrod has applied this model to a set of water resource projects, with interesting results. To derive a comprehensive set of weights in the manner suggested by Weisbrod, however, would impose staggering data requirements: nothing less than the net distributional and efficiency effects for all public expenditures would suffice.[56]

The procedures suggested by Weisbrod and Haveman for inferring a social consensus as to distributional weights are not convincing. Both writers infer distributional intentions on the part of legislators as the reason for actions which may have been influenced by other factors. Weisbrod's procedure is particularly susceptible to this criticism, since it assumes all deviations from the pursuit of efficiency in the decision-making process are explained by distributional considerations. Other government goals (such as ecological objectives in the water resource projects Weisbrod considers) may also cause such deviations, as may more mundane factors such as irrationality, log-rolling or other political considerations.[57] Nor is the incidence of taxation immune from such influences. Indeed from this point of view, one might question Haveman's selection of nominal income tax rates as having a special social significance: the actual incidence of the total tax system, which is much less progressive, might be considered a more appropriate indicator of legislative distributional intent.

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[54] Robert H. Haveman, *Water Resource Investment and the Public Interest* (Nashville, Tenn.: Vanderbilt University Press, 1965), pp. 133-34.

[55] Burton A. Weisbrod, "Income Redistribution Effects and Benefit-Cost Analysis", in *Problems in Public Expenditure Analysis*, pp. 177-209.

[56] See Robert H. Haveman's comment on Weisbrod's paper in *Problems in Public Expenditure Analysis*, pp. 209-213.

[57] Some of the problems in deriving distributional weights by this method are illustrated in Example 3, Chapter III.

Finally, one might ask whether Haveman and Weisbrod have performed anything other than interesting historical enquiries into the weights attached by past decision-makers to distributional effects. Weisbrod himself notes that "standards of distributional equity may be changeable over time"[58] and there seems to be no reason why legislators should be bound by the values of their predecessors. Weisbrod's methodology would seem particularly prone to this criticism, since it assumes that the political process permitted the achievement of a distributional optimum in the past, and one might presume that the same process could apply in the future, without the introduction of explicit distributional weights.

While the search for a unique set of weights which represent the "social welfare function" may well be considered unrealized or unrealizable, some of the difficulties inherent in such a search could be avoided by the use of another type of weighting function. Several writers have suggested or illustrated the use of welfare functions which are intended simply to formalize a decision-maker's own values, and to assist the decision-maker in making choices consistent with these values.[59]

It may nevertheless be doubted whether any single weighting function which assigns values to changes in the size distribution of income can adequately take into account the full range of distributional concerns. For instance, no calculation of changes in the static size distribution of income would reveal the changes in total income caused by the multiplier effects of public investments. Nor would calculations of changes in the static distribution of income reveal transfer effects which involve different people, but cancel out within regions or income classes. Yet the fact that some roadside vendors gain while others lose because of the opening of a new highway, for example, may well be of interest to decision-makers.

4. Separate presentation of distributional effects

The above considerations lead to the conclusion that separate presentation of the various distributional effects of projects is necessary. Such presentations need to be organized so that answers can be obtained to two questions: who or what is affected, and how?

4a. Who or what is affected?

Clues to the appropriate groupings of the Canadian population for purposes of classifying the distributional effects of projects are provided by an examination of the intent and effects of present federal programs. In the first place, such an examination reveals an interest in the impact of distributional effects on the population grouped by income classes, and a particular distributional bias is evident in this respect. As the Royal Commission on Taxation has stated:

> "In our opinion, there is a consensus among Canadians that the tax-expenditure mechanism (including transfers) is equitable when it increases the flow of goods and services to those who, because they have little economic power relative to others, or because they have particularly heavy responsibilities or obligations, would otherwise not be able to maintain a decent standard of living."[60]

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58 "Income Redistribution Effects and Benefit-Cost Analysis", in *Problems in Public Expenditure Analysis*, p. 180.

59 See Hettich, "Distribution in Benefit-Cost Analysis: A Review of Theoretical Issues", pp. 25-27, and Martin C. McGuire and Harvey A. Garn, "The Integration of Equity and Efficiency Criteria in Public Project Selection", *Economic Journal* 79 (Dec., 1969), pp. 882-93.

60 *Report of the Royal Commission on Taxation*, Vol. II (Ottawa: Queen's Printer, 1966), p. 10.

Research undertaken for the Royal Commission on Taxation revealed for the first time that the distribution of benefits from federal expenditures favours such low-income groups,[61] and this finding has subsequently been confirmed elsewhere.[62]

The effects of federal expenditures on the regional distribution of incomes in Canada are also of sufficient importance that they deserve to be separately identified in benefit-cost analyses of most proposed federal projects. Federal government goals of aiding low-income regions, or reducing regional income disparities, are evident in such matters as equalization payments to provinces, procurement policies, and major programs such as those of the Department of Regional Economic Expansion. This considerable emphasis on the regional effects of federal government policy reflects a political fact with interesting implications for welfare economics. As several Canadian writers have pointed out, maximization of national income or welfare may be an appropriate objective for government policy in a unitary state, but in a federation the presumption is that maximization of the well-being of the federation's component regions is of primary importance.[63] The principle underlying efficiency calculations in benefit-cost analysis, that costs and benefits should be added without regard to the individuals or areas in which they accrue, is clearly not the only objective of project evaluations in a federal state.

Finally, the federal government may have more specific goals than the general goals of aiding low-income people or low-income regions. Programs may be designed to aid specific categories of low-income Canadians for whom the federal government has special constitutional responsibilities, whose members are thought to be affected by discrimination in private sector labour markets or similar problems. Thus, federal programs exist for the specific purpose of raising the incomes of native peoples, women, those handicapped in the labour market by age or insufficient labour market experience, etc.

We may therefore conclude that distributional effects of projects should be primarily grouped according to the income classes of those affected and the geographical locations affected, but that other distributional dimensions, such as age, sex, and labour force status, may also be relevant where programs have specific categories of Canadians as target groups.

4b. What distributional effects are relevant?

There are limits to the types of distributional effects which should be considered in benefit-cost analysis of public projects. In the first instance, a benefit-cost analysis is no place to examine the incidence of any project costs which are derived from general government revenues. The analyst can safely assume that the distributional consequences of raising revenues to finance government expenditures will be unaffected by the need to finance an additional project, the significance of which will be marginal in relation to the totality of public expenditures.

The task of analyzing the distributional effects of project expenditures and of any project costs which are not financed from general government revenues is, however, sufficiently extensive. Factors which are not considered in the calculation of the efficiency effects of projects become relevant in an analysis of their distributional effects. Thus, an interest in determining the distributional impact of proposed projects may include determining the distributional impact not only of

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61 Irwin W. Gillespie, *The Incidence of Taxes and Expenditures in the Canadian Economy*, Studies of the Royal Commission on Taxation, No. 2 (Ottawa: Queen's Printer, 1964), Chapters 3 and 4.

62 David A. Dodge, "Impact of Tax, Transfer and Expenditure Policies of Government on the Distribution of Personal Income in Canada" *Review of Income and Wealth* 21 (March, 1975).

63 See Anthony Scott, "The Economic Goals of Federal Finance", *Public Finance* 19, No. 2 (1964), pp. 241-88; Walter Hettich, *Why Distribution is Important: An Examination of Equity and Efficiency Criteria in Benefit-Cost Analysis*, Economic Council of Canada Special Study No. 19 (Ottawa: Queen's Printer, 1971), pp. 6-7.

efficiency benefits and costs, but also of factors that are ignored in efficiency calculations, such as pecuniary or transfer items and the re-spending process generated by public expenditures.

It is useful to employ the distinctions noted above and organize presentation of the distributional effects of projects so that they can be compared with their efficiency effects. The procedure might be illustrated by an example considered earlier, a benefit-cost analysis of a proposed superhighway. Calculation of the efficiency benefits of the proposed highway will take the form of estimates of such factors as savings in time and economies in vehicle usage. An accompanying exhibit might indicate the distribution of these benefits. The relationship between transfer and efficiency effects might be explored in another exhibit. It could be explained that there will be increases in the incomes of those servicing the new highway and in the value of businesses which employ them, as well as increases in the value of property adjacent to the new highway. It should also be pointed out that there will be accompanying decreases in income and wealth in areas from which traffic will be diverted to the new highway. Accompanying tables could illustrate these transfer effects. In similar fashion, an additional exhibit might illustrate other aspects of the re-spending process generated by the new highway, such as the multiplier effects of its construction on incomes in the area and in other regions. At the same time, the decision-maker should be left in no doubt that other government actions would have similar multiplier effects in the economy, and the point could be illustrated by examples.

Wherever possible, it is desirable to use existing data sources in carrying out the above enquiries. For instance, regional input/output tables can be used to trace the multiplier effects of projects, and may convey valuable lessons in project evaluation in the process.[64] Nevertheless, most of the information the analyst needs will be specific to the project under consideration. Accordingly, care has to be exercised in choosing distributional classifications, since the costs of collecting data grow geometrically with the number of subclasses chosen. For instance, a breakdown of a program's benefits among three income classes and 10 provinces would require 30 separate distributional estimates, and adding a further breakdown by sex would double the number of estimates required.

Care also has to be taken in choosing distributional classifications in order to aid assimilation of information by the decision-maker. Where the number of distributional dimensions can be reduced, diagrammatic presentations may often be the most effective means of displaying distributional data. Diagram 5 presents an example from the 1972 federal government review of financing arrangements for post-secondary education, the objective of the diagram being to indicate how federal transfers of funds to the provinces for higher education varied with provincial income levels.

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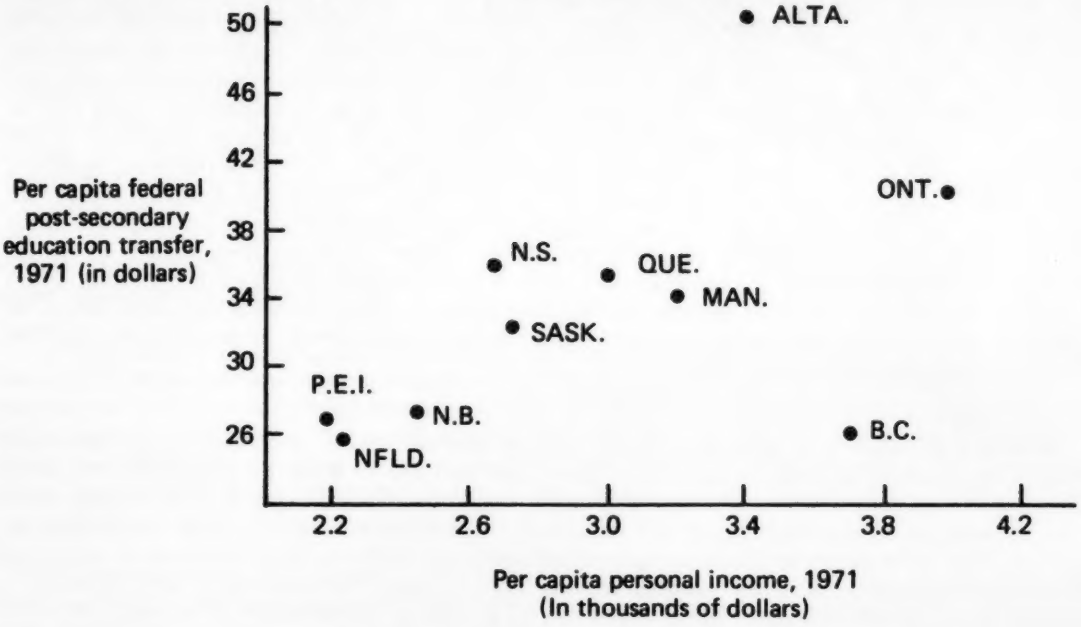
64 For an example of the use of regional input/output tables to calculate such regional multiplier effects, see John M. Hartwick, "An Interregional Input-Output Analysis of the Eastern Canadian Economies", Institute for Economic Research, Queen's University, Discussion Paper No. 2 (Sept. 1969). Hartwick finds that:

> "multiplier effects of expenditure in each of the Maritime Provinces are smaller than similar effects in the Rest of Canada. These results can be attributed to the fact . . . that leakages of economic flows from the Atlantic Provinces' economies are, relative to the size of the economies, much larger than leakages of economic flows from the Rest of Canada to each of the economies of the Atlantic Provinces." (p. 2)

Equally small local multipliers might be expected for expenditures in other regions that have large relative leakages in economic flows to the rest of Canada.

Diagram 5

Per capita federal post-secondary education transfer to provinces and provincial per capita personal income, 1971



4c. Target measures of distributional efficiency

A desire to summarize measures of distributional impact may also be accomplished by the development of target measures of distributional efficiency for programs which have the objective of redistributing income to specific categories of the population (for example, the poor and the aged). Several proposed measures of the target efficiency of distributional programs will now be considered.[65]

Measures of the accuracy of a program in assisting only the members of a target group have been termed measures of "vertical efficiency" by Weisbrod. While governments may approve programs with the intention of aiding those with low incomes, the actual beneficiaries of such programs may differ from their intended beneficiaries. In the United States, for instance, farm price support programs which were intended to augment low farm incomes have been found to benefit primarily the operators of large farms,[66] and low, heavily subsidized tuition rates in higher education have been found to benefit primarily upper-income individuals and families.[67] Two measures of the

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[65] For a more extensive discussion of such measures, see Burton A. Weisbrod, "Collective Action and the Distribution of Income: A Conceptual Approach", in *The Analysis and Evaluation of Public Expenditures: The PPB System*, pp. 177-197.

[66] See James T. Bonnen, "The Distribution of Benefits from Cotton Price Supports", in *Problems in Public Expenditure Analysis*, pp. 223-254.

[67] See W. Lee Hansen and Burton A. Weisbrod, "The Distribution of Costs and Direct Benefits of Public Higher Education. The Case of California", *Journal of Human Resources* 4 (Spring, 1969), pp. 176-191.

vertical efficiency of redistributional programs are the proportion of total program beneficiaries who are members of the target group, and the proportion of total program expenditures which accrue to members of the target group.

Other indicators of target efficiency attempt to measure the adequacy or comprehensiveness of programs in providing benefits to members of a target group. Two such measures of horizontal efficiency are the proportion of members of a target group aided by a program, and the proportion of target group needs which are satisfied by the program. These indicators measure different aspects of the distributional adequacy of programs. Given the equity principle that people in similar circumstances should be treated equally, programs which benefit only a few members of a target group should be considered less desirable than programs which benefit all members of the group. On the other hand, all members of a target group may receive benefits from a program, but the benefits may be inadequate in relation to needs. Indicators of need have been most often developed in the context of antipoverty programs, where concepts such as poverty income lines, income levels which distinguish the poor from the non-poor, have been devised.

The uses of these measures of target efficiency can be illustrated by an example from the field of social assistance. Several governments around the world have in recent years shown interest in replacing welfare programs for low-income people with some form of guaranteed annual income or "negative income tax" program. Present welfare programs are faulty, among other reasons, because they entail disincentives to work. For example, an individual who was receiving welfare but finds a job may forfeit all welfare benefits, thus being rewarded for his efforts by a 100 per cent tax on his incremental earnings. Negative income tax schemes are intended to restore work incentives by providing some guaranteed minimum annual income level and by specifying some graduated loss of benefits (or tax rate) as earnings rise above this income level. The need to provide work incentives by lower tax rates on earnings also means that families or individuals with incomes above the guaranteed annual income level will benefit from this reform.

Some of the proposals considered in the Joint Federal-Provincial Review of Canada's Social Security System, initiated in 1972, can be used to demonstrate the probable distributional consequences of this type of reform. Diagram 6 indicates the sensitivity of measures of target efficiency to deviations in support levels for one type of income supplementation scheme. The target group of the program is families or individuals having incomes below the low-income lines formulated by Statistics Canada, and the basic type of income supplementation scheme considered involves a guaranteed minimum annual income level which varies with family size,[68] graduated forfeiture of benefits as earnings rise above this level and assumptions concerning eligibility for the program.

Three measures of target efficiency are illustrated in Diagram 6. Percentage of income gap filled is a measure of horizontal efficiency, indicating what proportion of the shortfall of total family income from the Statistics Canada low-income line would be removed by the program. Two measures of the vertical efficiency of the program have been calculated; spending target efficiency indicates the proportion of total program cost which contributes to elimination of the low-income gap, and population target efficiency indicates the proportion of total program beneficiaries having incomes below the low-income line in the absence of the program.

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68 The guaranteed minimum annual income level for an individual or family lies below the corresponding low-income line for the same individual or family.

Diagram 6

Sensitivity of measures of target efficiency of an income supplementation scheme to variations in the support levels

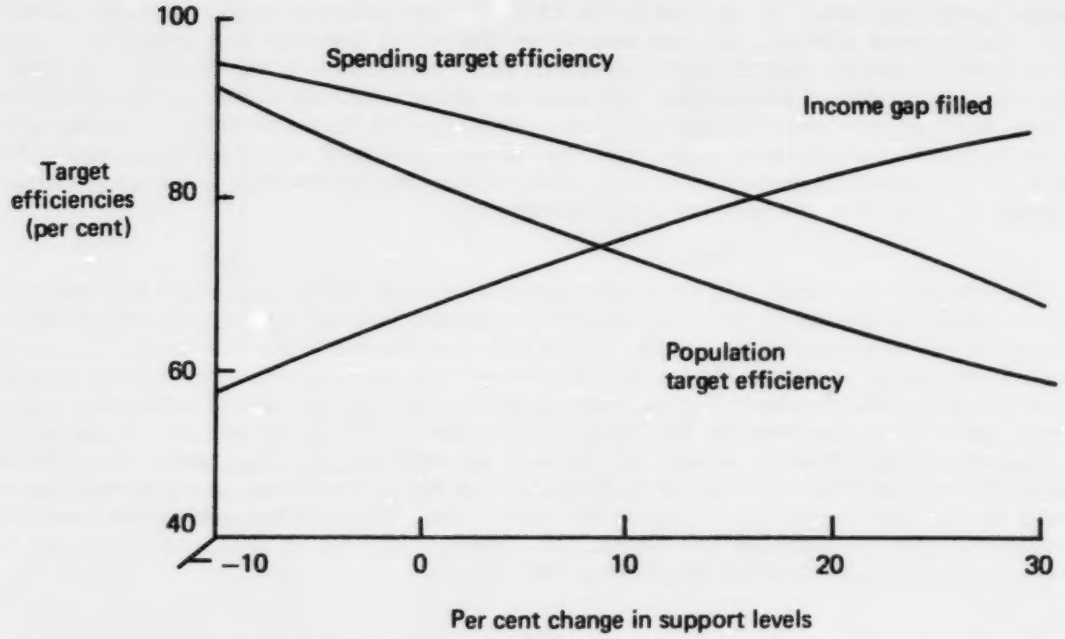

Diagram 6 illustrates the trade-off which occurs between program adequacy (horizontal efficiency) and measures of vertical efficiency as basic support levels are increased in this type of income supplementation scheme. As the program becomes more generous, additional low-income families benefit from the provisions and the low-income gap is reduced, but more higher-income families (outside the target group) also benefit.

This example and other considerations suggest that it may be wise to augment summary measures of the vertical and horizontal efficiency of distributional programs with disaggregated data on the incomes of people affected by these programs. In particular, it is pointed out in Example 2 of Chapter III that there are shortcomings in measuring the success of antipoverty programs with reference to poverty "line crossing", or "gap-reducing", criteria. These criteria suggest, for instance, that decision-makers are indifferent to any income gains above the poverty income line, whether such gains accrue to the highly affluent or to antipoverty program clients whose incomes have just been raised above the line. The criterion of closing the poverty income gap also assigns equal weight to given increases in incomes for those at the most severe levels of poverty and those who are only marginally poor. Finally, examination of actual poverty and low-income lines suggests that they are rather arbitrary as measures of need or income adequacy. For all of these reasons, the decision-maker may wish to assign his own price to program benefits accruing to different people, and disaggregated data on the income levels of program beneficiaries will enable him to do so.

5. Concluding remarks

The analyst serves an additional important function in collecting data on the distributional effects of projects. Where decision-makers have distributional objectives, the analyst should be able to advise them on how these objectives can be achieved at the lowest costs in efficiency terms. At present, we do not know the transformation function between efficiency and the major distributional objectives. For instance, we do not know what sacrifices in output are incurred if income is redistributed to the less fortunate by means of tax and transfer payments; nor do we know what efficiency costs are incurred if we pursue the same objective by means of spending on public works. Again, we do not know the trade-offs, in efficiency terms, between locating "footloose" government projects in high-income areas and in low-income areas. Until we know the costs of pursuing such objectives in terms of what we give up in efficiency, the process of rational allocation of public expenditures will therefore be inhibited. Accordingly, the analyst is assisting in the eventual establishment of such trade-offs by collecting data on the efficiency and distributional effects of individual projects.

CHAPTER III

APPLICATION OF BENEFIT-COST ANALYSIS

Steps in Benefit-Cost Analysis

Before providing three examples of benefit-cost analysis, a procedure for performing benefit-cost analysis on public investment proposals is outlined.

It is presented here as a sequence of steps, but this sequence should not be regarded as rigid. The person performing the analysis may often find it necessary to return to previous steps as the problem becomes more evident.

To conduct a benefit-cost analysis for an investment project, the analyst should proceed as follows:

- Identify the problem, clarify the issues and set the terms of reference.
- Clearly define and set the objective(s) of the investment.
- Generate alternatives that would meet the stated objective(s).
- Identify the constraints that exist within the environment of the investment and eliminate those alternatives that do not fall within the constraints.
- Examine each chosen alternative in detail. For each alternative:
  - List the benefits and costs and the underlying assumptions.
  - Quantify the benefits and costs.
  - Draw up a benefit-cost profile.
  - Calculate the indicators (net present value, benefit-cost ratio, internal rate of return) and test for sensitivity.
  - Identify and, whenever possible, provide quantitative measures of distributional effects.
- Finally, prepare the report comparing the results of the analysis for each alternative examined.

Obviously, the above steps cannot be performed by the analyst in isolation and will require consultations with the decision-maker and others, the gathering of a wide variety of information, and the use of a number of analytical techniques. It is important that as the analysis proceeds, the decision-maker is aware of, and in agreement with, the form the analysis is taking and the assumptions being made. If he is suddenly presented with a completed package without prior consultation, he may be reluctant to accept the results. Nevertheless, the decision-maker should not be expected to base his decision solely on the results of the analysis. He will usually consider these results along with other factors (for example, political considerations) in making his decision.

In some cases the purpose of the analysis will be to examine only one proposed project to determine whether or not it should be undertaken. The procedure to be followed would be the same as described above except that instead of comparing alternatives, the benefit-cost profile and values of the indicators are reported as the results of the analysis. In the following paragraphs each of the above steps is briefly described.

The problem

The first step entails an investigation and assessment of the problem. What are we doing? Why? For whom? Is our program or department meeting its mandate? Can we see ways to enrich our program? What are the terms of reference? What are the time limits?

Objectives

The second step in the analysis is to clearly define the objectives to be achieved by the investment. These will vary according to the point of view being taken and the level at which the analysis is being conducted. The project's investment objectives will be a sub-set of general government objectives and departmental or agency objectives. The statement of objectives should include:

- what the investment project is intended to accomplish;
- whom the investment project is intended to reach.

Alternatives

Once the objective(s) is defined, the alternatives must be identified. This search for alternatives requires imaginative thinking and critical analysis. It is important to keep an open mind when examining existing ways of doing things. The alternatives should be described in such a way that the essence of each alternative and the differences between alternatives are clear.

Constraints

There will invariably be constraints to meeting the objectives defined in the second step. These must be identified to ensure that all alternatives examined in the analysis are feasible. Some types of constraints might be classified as follows:

- Technological: what is possible within the present and predicted levels of technology.
- Legal: these could include a variety of things such as limitations on an agency, price restrictions, expropriations.
- Distributional: how must the effects of the project be distributed among individuals, provinces, or regions.
- Financial: there may be constraints upon total capital and/or operating expenditures.
- Social: limits on the effects and costs society as a whole is willing to bear.
- Administrative: limits on what can be handled administratively.
- Physical: limits on the availability of certain inputs required for a project.

All the alternatives must be measured for feasibility against these constraints. If a preferred alternative is excluded due to a particular constraint, there is a cost associated with observing that constraint. This should be brought to the attention of the decision-maker when presenting the results of the analysis.

Benefits

For each alternative a list of benefits must be drawn up. The effects of a project which are regarded as benefits will depend on the list of objectives as identified in the second step. Depending on the choice of objectives the list of benefits might include such items as:

- value of output
- scrap value of equipment
- increase in productivity
- decrease in unemployment
- research and development spillovers
- increase in standard of living and quality of life
- environmental and health improvements
- other positive technological externalities

Costs

Similarly, for each alternative a list of costs must be drawn up. Examples of costs are:

- capital expenditures
- operating costs
- maintenance costs
- labour costs
- costs of inputs (raw materials and intermediate manufactured goods)
- research and development costs
- opportunity costs associated with using land and/or facilities already in the public domain
- other negative technological externalities

Quantification

Now a value must be determined for each benefit and cost wherever possible, preferably in monetary terms.

Benefit-cost analysis differs from private financial analysis in that projects are evaluated from the viewpoint of efficient resource allocation as opposed to private profits and losses. The analyst considers the benefits and costs of projects to society as a whole, rather than to narrower entities such as private business firms. While accounting data and market prices provide the basic source of information, they often have to be modified to convert private benefits and costs into social ones. The following are examples of adjustments often required.

1. Value of final outputs

While private firms will net out excise and other taxes on final outputs in calculating their revenues, the social benefits arising from the consumption of outputs are determined by what consumers are willing to pay for them, and should therefore include the taxes on outputs.

2. Value of material inputs

Taxes on material inputs increase the price private firms have to pay for them, while subsidies reduce it. From a social point of view, if the material inputs for the project come from new supplies and are not diverted from other users, costs should reflect the costs of the resources needed to produce the material inputs. On the other hand, if the material inputs are obtained at the expense of other users, then the appropriate valuation of costs is market prices, which represent the marginal value of the inputs in other uses.

3. Interest on borrowed capital

Interest, while relevant for financial analysis in a cash-flow sense, has no relation to the value of real resources required. It should therefore be ignored in estimating costs.[69]

4. Depreciation allowances

Depreciation charges are purely a bookkeeping device and therefore should not be included as a cost.

5. Land

The value of land should be determined by its opportunity cost, that is, what it could produce in its next best use. If there is a reasonably free market for land, the market price of land or its rent will adequately measure its opportunity cost. If a public project uses government-owned land that has no market price or rent, shadow price for land has to be estimated. A method frequently used is to find land in the private sector with similar characteristics, such as location and proximity to transportation facilities and services, and use its market price as the shadow price.

Furthermore, for distributional and other effects that cannot be quantified in monetary terms, it is important to identify and quantify them for consideration by the decision-maker.

The benefit-cost profile and indicators

To facilitate comparison between alternatives, a graphic profile of total costs and total benefits occurring in each time period should be drawn up. If all the costs and benefits are expressed in monetary terms, they have to be discounted to their present value before a meaningful comparison can be made. After this is done, the benefit-cost indicators can be calculated in order to compare the alternatives. As mentioned previously, the most important indicator is the net present value.

It is suggested that all analyses be tested for sensitivity to the discount rate. Sensitivity analysis of specific costs and benefits should also be done if there is doubt as to the actual benefits or costs.

Assumptions

It is important that all assumptions which have been made during the analysis are clearly stated. The decision-maker must be made aware that the results of the analysis are based on these assumptions. Faulty assumptions could lead to an erroneous decision. Certain assumptions are made at each step in the analysis. In addition, assumptions are made as each benefit and cost is itemized and evaluated.

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[69] As a return to capital, interest is of course relevant for estimating the social discount rate, as discussed on pages 25-26.

The report

After all these steps have been completed, the results must be presented to the decision-maker. The decision-maker can then examine the information provided on the relative merits of each alternative and combine this with his own judgment and knowledge of the situation to arrive at a decision as to which alternative to adopt. The results may be presented in a written or oral report, or both. A written report should include:

- a summary of the results of the analysis;
- an introduction describing the situation which has led to the performance of a benefit-cost analysis;
- the objectives of the proposed investment as viewed by the analyst;
- a description of the alternatives considered;
- the constraints considered in conducting the analysis and the alternatives selected;
- the cost-benefit profile (perhaps in graphic form) and values of relevant indicators for each alternative;
- a list of assumptions made in performing the analysis, and information on how benefits and costs were estimated;
- a description of distributional effects and their quantitative indicators;
- a conclusion discussing the results of the analysis and how they might be considered.

The report should be short and concise. The background work which went into the analysis should be available as one or more supplementary reports which may be referenced in the main report and which are available on request.

Examples of benefit-cost analysis

Practical applications of the principles and procedures set out in the previous sections of this Guide are illustrated in the three following examples drawn from experience in the federal government or from Canadian publications. Example 1 represents an application of benefit-cost analysis in the field of water resource development. Much of the methodology of benefit-cost analysis has evolved in this and other areas concerned with natural resource development. The figures used in this example are hypothetical. Examples 2 and 3 were chosen because they represent examples of benefit-cost analysis in areas where federal government participation has rapidly expanded in recent years, namely, health, manpower and welfare programs.

Among other matters, the examples illustrate the earlier discussion in the *Guide* of the following subjects:

The examples represent uses of benefit-cost analysis from different standpoints. Example 1 uses benefit-cost analysis to predict the outcome of a proposed program. Examples 2 and 3 represent the retrospective use of benefit-cost analysis to measure the consequences of completed programs.

All of the examples indicate how shadow prices may be used to value the outputs of public projects. In Example 1, riverbed improvement and the construction of a dam are expected to lead to the prevention of flood damage, and such prevented costs can be measured. Because some of the land can now be irrigated due to the dam construction, the increased output of

the irrigated land can be valued. As well, a reservoir is to be created whose uses for recreational purposes can be valued. The training program studied in Example 2 increased the productivity of workers, and the increase in the earnings of trainees is used as a proxy for the value of increased output made possible by the program. A similar methodology is conventionally used in measuring the benefits of other education-type programs. Example 3 values the direct benefit of a tuberculosis detection program as being the treatment costs saved by early detection of the disease. The increase in patients' earnings made possible by early detection of the disease and the consequent reduced hospitalization time constitute the indirect benefits of this program. Finally, the early detection of the contagious disease leads to external benefits, in that other members of the population are prevented from being infected. The savings from these external benefits are relatively large in this program, as they often are in similar health programs.

Examples 2 and 3 also introduce distributional considerations into evaluation of the projects concerned. The analysis of the health program reveals the implicit redistributive effects of the program in the locations in which it was conducted. The analysis of the training program evaluates how well it succeeded in meeting its explicit distributional objectives, which were to raise the incomes of the poor and to make them "non-poor".

Examples 1 and 2 represent efforts to deal with the effects of uncertainty on parameters of analyses. In deriving estimates of the benefits from the programs concerned, Example 1 makes use of probability theory and Examples 1 and 2 make use of sensitivity analysis.

Finally, Example 1 is presented according to the outline given at the beginning of this chapter in an effort to show the step-by-step procedure used in performing a benefit-cost analysis.

Example 1: A flood control project

1. Problem and objective

Periodic floods in the spring and drought conditions in the summer in a river basin in the Prairies are a cause of economic loss and social hardship to the people in the basin. The affected area encompasses 6,000 square miles, has a population of 50,000 persons and includes several towns. In addition to flood hazard, these towns suffer from periodic water shortages for municipal and industrial use.

The objective of this investment is to manage the water and related resources of the river for the socioeconomic well-being of the residents of the region.

2. Alternatives considered

- Relocate the affected population.
- Dam the river to provide flood control and provide a recreational area.
- Dam the river to provide flood control only.
- Dike the river to provide some flood protection and develop ground water for irrigation.
- Dike the river to provide some flood protection and divert water from another river for irrigation during drought periods.
- Control flooding through a joint Canada/U.S.A. water control project on the river.
- Develop alternative land uses.

3. Constraints

3a. Physical

The project must not reduce existing arable land.

Ground water is insufficient in quantity and unfit for human consumption in the natural state because of salinity.

3b. Technological

It is anticipated that technology is adequate for any of the alternatives.

3c. Political

There is political pressure for action from the affected region.

There is a government policy to alleviate hardships on the farm.

Joint Canada/U.S.A. projects are susceptible to delays due to legal and political obstacles.

3d. Financial

A financial ceiling has not been placed on this project although it is understood that budgetary considerations might favour one project over another.

3e. Social

The affected population is reluctant to relocate.

3f. Environmental

The natural topography of the region makes gravity diversion impossible.

Damming of the river in the U.S.A. would cause damage to wildlife refuges.

Existing land conditions and the short growing season limit the type of crops that can be grown.

3g. Target

The target date for completion of the project is three years.

4. Selected alternatives

- Construct a dam on the river and provide a recreation area.
- Only construct a dam on the river.

The other alternatives were eliminated because of the constraints, leaving these as the only two feasible alternatives in meeting the objective.

5. Assumptions

- It is assumed that farmers are willing to irrigate 10,000 acres of valley land if water supply is guaranteed.
- An earthen dam has a useful life of 50 years.
- The combined growth in population and demand for recreational facilities is assumed to be 3.25 per cent per annum.
- A three-year planning and construction period is reasonable for this project.

6. Costs

6a. Project costs

As previously stated, the time required from initial planning to final construction of the project is three years. In the current year, an estimated $300,000 is required for engineering studies, followed in the two ensuing years by $750,000 and $1,500,000 for construction of the dam and irrigation facilities respectively. The present value of this cost stream of dam and irrigation facilities is $2,221,500 at a 10 per cent discount rate.

In addition, it is estimated that $30,000 will be required in operating and maintenance costs each year over the 50-year life of the project. The present value of this cost stream is $245,800. Therefore, the present value of the sum of the capital and operating and maintenance cost streams is $2,467,300, assuming a 10 per cent discount rate.

6b. Recreational costs

In order for the reservoir to be used as a source of recreation, an initial investment of $50,000 will have to be made in the third year for facilities. Additional investments of $20,000 will be required at 10-year intervals thereafter for replacement and for expansion to accommodate the projected growth in usage. The present value of these costs is $51,500.

The estimated level of operating and maintenance costs for the recreation site is $15,000 per annum adding an additional $122,900 to the present value of the cost stream at a 10 per cent discount rate.

6c. Potential sources of costs (non-quantified)

The principal guide in identifying alternative sources of costs is to examine the impact on the resource or input base. Such effects as increased silting upstream requiring additional expenditures on dredging, or ecological effects, such as the flooding of game or bird sanctuaries, should be included in the analysis. It is important that a project be examined within the context of the relevant system so that the linkages can be identified.

7. Benefits

7a. Reduction of flood damage

The primary source of benefits is the expected level of reduction in flood damage as a result of the project being undertaken. If the project is implemented, benefits from this source can be expected starting in the fourth year, that is, after construction has been completed. The manner in which the magnitude of these benefits is calculated is indicated in Table 4. The alternative levels of flow above flood level during the spring thaw are specified together with their corresponding probabilities of occurrence. Associated with each rate of flow is a level of damage which measures the amount of damage that can be expected if the specified rate of flow occurs.

Given that the project is undertaken, the rate of flow above flood level in the river basin will be reduced as indicated in Table 4. The higher the rate of flow, the less will be the capability of the dam in controlling this flow, so that the percentage reduction in flow above flood level declines as the rate of flow increases. The rate of flow which remains above flood level can then be translated to expected damage levels as a result of this residual flow.

This information provides a sufficient basis for calculating the expected levels of damage both with and without the dam and associated works. The difference between these two figures is a measure of the reduction in the level of flood damage which can be expected should the project be undertaken. As indicated in Table 4, this is calculated to be $182,510 per annum. The present value of this benefit stream over the 50-year life of the project, using a 10 per cent discount rate, is $1,495,500.

7b. Irrigation benefits

A second source of benefits is the increased revenue on the 10,000 acres of land that are irrigated. The *incremental* net return per acre irrigated is assumed to be $20. The net return is calculated by deducting the increased costs (for example, seed, fertilizer and water) from the higher revenue due to an increase in crop yield per acre. Thus, the yearly benefits are $200,000. The present value of this benefit stream is $1,638,800, using a 10 per cent discount rate.

7c. Recreational benefits

As noted above, a reservoir will be created which can be utilized for recreational purposes following completion of the project. It is estimated that initially the utilization of this reservoir will amount to 13,800 user days. Based upon the observed expenditures, including travelling costs, of participants in similar recreational facilities, the value of each user day is estimated to be $2.00.[70] The rate of usage, however, is expected to grow because of population growth and because of the increasing affluence of the population which results in greater participation in recreational activities. This rate of growth in utilization is calculated to be 3.25 per cent per annum. Hence, by the end of the time span considered, the number of user days is expected to be 66,150. The present value of benefits from recreation is calculated to be $323,700.

7d. Potential sources of benefits (non-quantified)

There are a number of potential sources of benefits, some of which are noted below. For example, the dam might be constructed as a hydroelectric dam, in which case the output of electricity would constitute a benefit to be included with those already calculated. Alternatively, the reservoir might constitute not only a recreational facility but also a source of water for surrounding communities. Also, as a result of the reduction in river flow, new land may be made available downstream which can be valued according to its potential usage.

The point to be stressed is that benefits represent the valuation of potential increase in outputs of goods or services given the project under consideration. The reduction in flood damage, in particular, is a direct reflection of this since the values used in assessing damage reflect the valuation of the expected outputs of the facilities or land involved. Hence, a potential impact upon output is a candidate for consideration. If the output is "good", for example, recreation, it is added to the benefit stream. If it is "bad", for example, pollution, it is deducted from the benefit stream.

A summary of the costs and benefits over time is presented in Table 5. The net present value of benefits and costs for the two alternatives are compared in Table 6. Table 7 demonstrates the sensitivity of the net present value and benefit-cost ratio to the discount rate.

8. Conclusion

Alternative 1 is preferable to Alternative 2 although both projects are feasible at a discount rate of 10 per cent.

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70 For an excellent treatment of how recreational benefits can be estimated, see A.C. Fisher, J.V. Krutilla, and C.J. Cicchetti, "Alternative Uses of Natural Environments: The Economics of Environmental Modification in Natural Environments", in *Studies in Theoretical and Applied Analysis*, ed. J.V. Krutilla (Resources for the Future, Washington D.C., 1972), and J.L. Knetsch, *Outdoor Recreation and Water Resources Planning* (American Geophysical Union: Washington D.C., 1974).

TABLE 4

Expected reduction in flood damage

Flow above flood level (feet)	Probability of occurrence	Associated damage	Percentage reduction	Resulting flow above flood level (feet)	Resulting damage
100	.50	$ 16,000	100	0	$ 0
200	.20	80,000	95	10	200
300	.15	180,000	80	60	7,200
400	.10	500,000	60	160	51,200
500	.05	2,000,000	30	350	245,000

Expected damage levels

Without dam:

= (.50) (16,000) + (.20) (80,000) + (.15) (180,000) + (.10) (500,000) + (.05) (2,000,000)
= $201,000

With dam:

= (.50) (0) + (.20) (200) + (.15) (7,200) + (.10) (51,200) + (.05) (245,000)
= $18,490

Expected level of damage reduction

= $201,000 – 18,490
= $182,510

TABLE 5

Benefit-cost matrix (in dollars)

Year	0	1	2	3	.....	52
Benefits						
Flood damage reduction	0	0	0	182,510	.....	182,510
Irrigation	0	0	0	200,000	.....	200,000
Recreation*	0	0	0	27,600	.....	132,300
Costs						
Capital construction	300,000	750,000	1,500,000	0	.....	0
O&M (project)	0	0	0	30,000	.....	30,000
Recreational facilities** (construction and replacement)	0	0	50,000	0	.....	0
O&M (recreational facilities)	0	0	0	15,000	.....	15,000

* The annual rate of growth in utilization is 3.25 per cent.

** The recreational facilities are replaced every 10 years (i.e., years 12, 22, 32, 42) at a cost of $20,000.

TABLE 6

Comparison of alternatives
(10 per cent discount rate)

	PV benefits	PV costs	NPV	B/C
Alternative 1 Dam and recreational facilities	$3,458,000	$2,641,700	$816,300	1.31
Alternative 2 Dam only	$3,134,300	$2,467,300	$667,000	1.27

TABLE 7

Sensitivity analysis of discount rates

		5 per cent	10 per cent	15 per cent
Alternative 1 Dam and recreational facilities	NPV B/C	$3,119,900 1.93	$816,300 1.31	–$71,300 0.97
Alternative 2 Dam only	NPV B/C	$2,709,100 1.88	$667,000 1.27	–$148,000 0.93

Example 2: Benefit-cost analysis of an antipoverty training program

This example assesses the success of an antipoverty training program in terms of its allocative and distributional effects.[71] The allocative assessment involved calculation of the present value of the allocative benefits and costs for the project, while the distributional success of the project was evaluated in terms of the degree to which the incomes of the poor were raised by training. Besides assessing the allocative and distributional effects of the *total program,* analysis was also undertaken to assess the effectiveness to society of on-the-job and institutional training for men and women separately.[72]

1. Allocative costs of training

Two components of training costs were distinguished – the costs of operating the program and the output loss to society of withdrawing trainees from the economy.

1a. Program expenditures

The program's administrative staff was not involved with the actual training of its clients. The staff recruited trainees, checked on their progress during training, and attempted to find jobs for them after training. The cost of these overhead functions was estimated to be $1,106 per trainee, although it was felt that this figure overstated the costs attributable to training, since it also included some expenditures on services provided to non-trainees.

1b. Direct course costs of institutional training

The direct course costs of institutional training, obtained by government audits of the courses involved, amounted to $445 for each institutional trainee and $546 for each male institutional trainee. These costs, as officially compiled, overstated actual course costs since total expenditures for equipment purchases were charged against the courses involved with no allowance being made for future use of this equipment in other training courses. Moreover, some trainees sponsored by the project were responsible for little in the way of marginal training costs since they were placed on short notice in courses that would otherwise have been run with some vacancies. These factors leading to overestimation of institutional training costs were at least partly counterbalanced by the fact that no provision was made for the opportunity cost of the buildings used for this type of training.

1c. Opportunity costs of institutional trainees

Society also incurred costs in the form of foregone output while the project's clients were participating in institutional training courses. This loss was valued by estimating what these trainees would have earned had they not been in training, and deducting from this sum any trainee earnings from part-time employment during the institutional training courses. To estimate the alternative earnings of trainees, a regression was run for a control group of comparable non-trainees, with weekly earnings during the training period being the dependent variable, and a wide range of worker characteristics (such as sex, age, race, education, physical handicaps, prior labour force experience and marital status) being the independent variables. The regression coefficients for earnings associated with the various characteristics were weighted by the proportion of institutional trainees

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71 This section is based on Chapter IV of D.O. Sewell's, *Training the Poor* (Kingston, Ontario: Industrial Relations Centre, Queens' University, 1971), pp. 83-105. This chapter is also reprinted in *1971 Annual on Benefit-Cost Analysis*, ed. A.C. Harberger *et al.* (Chicago, Aldine-Atherton, 1972). While benefit-cost ratios were used in the original study, the results are presented in terms of net present values in this *Guide*.

72 No analysis was undertaken of the effectiveness of institutional training for women, since regression analysis revealed that there was no increase in earning levels associated with the training of these clients of the program.

having the characteristics in question in order to estimate what institutional trainees would have earned had they not been in training. After deducting earnings from part-time employment during training, this opportunity cost amounted to $516 for each institutional trainee and $791 for each male institutional trainee.

1d. Costs of on-the-job training

The only direct course costs incurred for this type of training were federal subsidies to employers averaging $68 for each female trainee and $107 for each male trainee. Regression analysis (along the lines employed to find the opportunity costs of institutional trainees) revealed that the expected hourly wages on-the-job trainees would have received had they not been in training were below the legal minimum-wage levels employers were required to pay during the training period. It was therefore concluded that on-the-job trainees incurred no opportunity costs during the training period, and that the federal subsidies to employers for providing on-the-job training partly represented reimbursement for administering a transfer payment. In view of the minor sums involved, it was not felt worthwhile to make further enquiries as to what proportion of the subsidy represented allocative costs to society and what proportion represented a transfer payment to trainees. The treatment of the total employer subsidy as being an allocative cost to society consequently represents an overestimation of the costs of on-the-job training.

1e. Indirect costs of training

Total costs for services performed by the federal government in administration and supervision of training were calculated to be $13 for each female on-the-job trainee, $21 for each male on-the-job trainee, and $70 and $87 for each institutional trainee and male institutional trainee respectively.

1f. Total costs of training

Total average costs per trainee resulting from the above calculations were $1,187 for each female on-the-job trainee, $1,233 for each male on-the-job trainee, $2,137 for each institutional trainee, $2,530 for each male institutional trainee, and $1,503 for *all* persons trained by the program.

2. Allocative benefits to society

The present value of allocative benefits was calculated using the formula:

$$Va = \sum_{N=A}^{64} \frac{YaPN(1+X)^{N-A+1/2}}{(1+R)^{N-A+1}}$$

where: Va = the present value of all allocative training benefits from age A (the average age of the respondents at the end of training) through age 64.

Ya = the annual increase in earnings associated with training for a period averaging 16 months after training was completed.

PN = the number of survivors at age N.

R = the rate of discount used to convert future earnings to their present values.

X = the annual increase in earnings levels due to rising productivity over time.

A more detailed discussion of the nature of these variables and the values assumed for them follows.

2a. The annual allocative benefits from training in the survey period

Following conventional practice in assessments of the returns to education and other investments in human capital, the increase in earnings levels associated with training was treated as a proxy for the increase in output made possible by training. Earnings data were collected for a period averaging 16 months after completion of training for both trainees and the control group of non-trainees who were eligible to participate in training. Regression analysis was employed to determine the increase in earnings levels associated with training, net of the influence of a wide range of worker characteristics which were also found to be associated with differences in the earnings levels of individuals. On an annual basis, the increase in earnings associated with training in the survey period amounted to $433 for the average individual trained by the program and $756 for each female on-the-job trainee, $429 for each male institutional trainee and $384 for each male on-the-job trainee.

2b. The secular rate of growth in real earnings

The net annual increases in earnings found to be associated with training in the survey period were next projected into the future. These earnings differentials were first adjusted to allow for the effect of rising real earnings levels over time. However, future earnings levels of trainees were not adjusted by the total expected growth rate in the economy, since part of this growth rate is attributable to increases in the quality of the labour force brought about by just such investments in human capital as in the program being evaluated. Twenty-five per cent of an estimated future growth rate of 2.4 per cent per annum was attributed to such improvements in the quality of the labour force, and consequently the increase in earnings associated with training was adjusted upwards by (.75 x 2.4) or 1.8 per cent per annum for the years following the survey period. In view of the considerable uncertainty surrounding future growth in real earnings levels, however, the sensitivity of the projections to alternative annual growth rates of zero, one and two per cent was also examined.

2c. Assumptions concerning the remaining working lifetime of trainees

These benefits from training were assumed to persist over the remainder of the working lifetime of trainees. The average age of trainees was 32 years at the completion of training; it was assumed that they would retire at age 65, and life tables were used to correct for the possibility of death before age 65.

2d. The social discount rate

A social discount rate of 10 per cent per annum was used to obtain the present value of the lifetime stream of training benefits at the time costs of training were incurred.

2e. Total allocative benefits from training

Estimates of the allocative benefits from training based on the total annual benefits in the survey period, including the effects of increased employment, a 1.8 per cent growth rate in real earnings and a social discount rate of 10 per cent, are shown in Table 8.

3. Net present value of allocative benefits and costs

Table 8 also reveals that using the above values for total benefits, the net present value for the training program as a whole was positive. Moreover, it should be noted that this amount represents a conservative estimate of the efficiency of the program. No benefits from training, other than increases in earnings, were considered in deriving the net present value, and the costs of training were overestimated in ways discussed above. Finally, Table 9 summarizes the allocative benefits and net present values from training, based on alternative assumptions about the increase in earnings levels arising from economic growth. The combination of the most pessimistic of these assumptions employed in valuing training benefits fails to upset the conclusion that the training program as a whole added more to output than it cost.

Subsidiary objectives in the analysis of the allocative effects of the program were to compare the allocative benefits and costs of on-the-job and institutional training, and of training men as opposed to training women. The analysis revealed on-the-job training to be a more efficient use of society's resources. The findings with respect to the relative advantages of training men and women were mixed. On one hand, institutional training was associated with no increases in the earnings of women, and this type of training consequently represented an inefficient use of society's resources. On the other hand, Table 8 indicates that on-the-job training for women was a more efficient use of society's resources than either on-the-job or institutional training for men.

4. The distributional effects of training

The project evaluated was part of an antipoverty program whose explicit objective was to change people from poor to 'non-poor' through their own efforts. The final step in the evaluation of the project was to determine its success in meeting this distributional objective.

Regression analysis of the data from the survey of trainees and non-trainees was first used to find the average earnings levels of trainees with and without training.[73] These earnings levels were then compared with poverty income lines to determine whether the training program was successful (a) in raising the earnings levels of its clients above these poverty lines, or (b) in closing the poverty income gap, that is, the dollar amount by which the earnings levels of trainees fell short of the poverty lines.

Two sets of poverty lines were used, one constructed by Friedman and the other by Orshansky. The first step taken by both writers in deriving their poverty lines was to estimate the minimum expenditures necessary to provide an adequate diet for families of varying sizes.[74] However, both authors acknowledge that no satisfactory generalizations can be made about the adequacy of non-food expenditures of households. Orshansky in fact derived her poverty income lines by multiplying her estimates of minimum-adequacy food budgets by three, on the grounds that food expenditures make up roughly one-third of the expenditures of the average family. Friedman derived her poverty income lines by multiplying her estimates of minimum-adequacy food budgets by 1.67, on the grounds that this is the average relationship for people who are actually on the margin of adequate nutrition.

Examination of Table 10 reveals that earnings increases associated with training were insufficient to push any category of trainees above Orshansky's poverty lines. Male on-the-job trainees came closest to crossing the line and closed the poverty income gap to only $216. The paradox is that using Friedman's poverty lines, the average male on-the-job trainee would not have been considered poor even if he had never been trained. However, training proved to be successful in pushing all other categories of trainees distinguished in Table 10 over Friedman's poverty lines.

It is necessary to recognize the shortcomings of measuring the success of an antipoverty program by reference to these line-crossing or poverty-gap-reducing criteria. In the first place, these criteria suggest that society is indifferent to any income gains which accrue to antipoverty program clients once their incomes are higher than the poverty lines. A second deficiency of the

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73 The procedure employed to estimate what the earnings levels of trainees would have been without training has already been illustrated in deriving the opportunity costs of institutional trainees.

74 Rose D. Friedman, Poverty: *Definition and Perspective*, Washington, D.C.: American Enterprise Institute for Public Policy Research, 1965, and Mollie Orshansky, "Counting the Poor: Another Look at the Poverty Profile", *The Social Security Bulletin* 28, (January, 1965), pp. 3-29. Orshansky's estimates of minimum-adequacy food budgets also vary with the sex of the head of the household and with the location of the household, whether farm or non-farm. Adjustments were made for these factors in using Orshansky's poverty lines in the study under review.

line-crossing criterion is that an anti-poverty program is judged to be a failure if it fails to raise the incomes of its clients above the poverty lines, even if it does raise their incomes substantially. Another deficiency of the criterion of closing the poverty-income gap is that it assigns equal weight to given increases in income below the poverty lines, regardless of what the initial income levels of antipoverty program clients are. Yet it is reasonable to argue that a concern for reducing poverty implies a preference for ameliorating the condition of those people at the most severe levels of poverty. Hence income gains to those at very low income levels should be viewed more favourably than income gains to those who, while still poor, have slightly higher incomes.

The defects of the line-crossing or poverty-gap-reducing criteria listed above make these criteria unappealing, and use of these criteria is rendered doubly unattractive in view of the arbitrariness used in constructing existing poverty income lines.[75] Correcting for the deficiencies of these criteria would involve weighting increases in incomes around poverty income lines, with the weights increasing as the initial income levels of antipoverty program clients decrease. Such a weighting scheme also permits integration of assessments of the allocative and distributional effects of programs. The practical problems involved in applying such criteria, of course, lie in choosing the poverty lines and the weighting system to be used. Nevertheless, it is possible to indicate roughly how the application of these criteria would affect the evaluation of the training program studied. A comparison in which the net present values for the various training categories were weighted by consideration of what trainees' incomes would have been without training would reflect most favourably on on-the-job training for women. Women on-the-job trainees would have had lower incomes without training than other categories of trainees, and (if the employment effects associated with training are counted as allocative benefits) the net present value from their training was higher than that for any other category of trainees.

As has been seen, an unweighted comparison of the net present values of on-the-job and institutional training for men is unfavourable to institutional training. A weighted comparison would be more favourable to institutional training for men, since without training, the incomes of these trainees would have been $445 less than the average annual earnings of male on-the-job trainees.

Finally, it should be noted that the net present values for this project as a whole would benefit from a weighted comparison with other antipoverty programs, since few if any published benefit-cost analyses of such programs have dealt with populations having as low levels of income.

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[75] The poverty lines of Orshansky and Friedman lose much of their appeal when the income levels they yield are seen to depend on the question of whether minimum-adequacy food budgets should be multiplied by factors of either 3.0 or 1.67.

TABLE 8

Net present value of allocative benefits and costs per trainee (in dollars)

Item	On-the-job training for women	On-the-job training for men	Institutional training for men	All trainees
Present value of allocative benefits	8113	4014	4396	4623
Present value of allocative costs*	1187	1233	2530	1503
Net present value	6926	2781	1866	3120

* Allocative costs per trainee were a weighted sum of on-the-job and institutional training costs. The weights were the proportions of sample members in each type of training; that is, 31 per cent of trainee sample members were institutional trainees, 24 per cent were female on-the-job trainees, and 45 per cent were male on-the-job trainees.

TABLE 9

Allocative benefits and net present values for training categories under alternative assumptions concerning secular rates of growth in earnings at a social discount rate of 10 per cent

Training category	Allocative benefits from training (in dollars)				Net present values from training			
	Annual rates of growth in earnings (per cent)				Annual rates of growth in earnings (per cent)			
	0	1.0	1.8	2.0	0	1.0	1.8	2.0
Female on-the-job trainees	6902	7536	8113	8268	5714	6349	6926	7082
Male on-the-job trainees	3428	3735	4014	4089	2195	2502	2781	2857
Male institutional trainees	3772	4100	4396	4476	1240	1569	1866	1947
All trainees	3936	4296	4623	4711	2434	2794	3120	3206

TABLE 10

Poverty lines and the increases in earnings associated with training (in dollars)

Training category	Poverty lines in annual income levels		Average annual earnings levels after training	
	Following Friedman	Following Orshansky	Without training	With training
Female on-the-job trainees	1800	2341	1101	1857
Male on-the-job trainees	2213	3118	2516	2902
Male institutional trainees	2213	3118	2073	2502
All trainees*	2213	2877	1973	2406

* The poverty level for all trainees following Orshansky's criteria was derived by assigning a weight of .69 to her poverty line for a non-farm family of four headed by a male and a weight of .31 to her poverty line for a non-farm family of three headed by a female. These weights reflect the proportions of males and females in our sample.

Example 3: Analysis of a tuberculosis control program

The following is an example of benefit-cost analysis used to evaluate the operation of an X-ray tuberculosis screening program that examined 264,560 people during 1964.[76] The program's objective was to detect active cases of tuberculosis at an early stage of the disease.

The benefits from the program were defined as:

- Direct – the reduced cost of hospitalization and other treatment due to the early detection of active cases of the disease
- Indirect – reduction in productivity loss due to early detection of illness and an earlier return to work of those found to have the disease
- External – reduction in the spread of the disease by detection of active cases

The calculation of direct benefits involved tabulation of with-program and without-program hospitalization costs. To do this it was necessary to: (a) classify the cases found by screening according to the degree of morbidity (severity) of each case; (b) similarly calculate how advanced the cases would normally have been without the program; (c) determine the length of hospitalization required for treatment of the disease; and (d) determine per diem costs of treatment.

The first step was accomplished by categorizing morbidity as minimal, moderate or severe. There were 13, 24 and 12 such cases respectively detected, for a total of 49 cases. Without screening, the number and morbidity of cases of the disease would have been 6.9 (minimal), 23.0 (moderate) and 19.1 (severe), for a total of 49 cases. The latter distribution was arrived at by assuming that the 49 cases would have been detected in roughly the same pattern as other cases that are found without screening. The number of days of hospitalization required to treat each degree of severity was estimated to be 205.2 days (minimal), 277.9 days (moderate) and 370.8 days (severe). Per diem hospitalization costs were assumed to be $19.53, irrespective of the degree of severity of a case. Therefore, the number of cases multiplied by the required days of hospitalization, multiplied by per diem costs, equal total costs of treatment. Treatment costs would accordingly have been $290,723 without the program and $269,221 as a result of earlier detection of the disease with the program. Total direct benefits from the program equal the difference between the two costs, or $21,502.

An indirect cost to society of a disease like tuberculosis is the output foregone because those detected to have the disease are withdrawn from the labour force during treatment. Thirty-eight members of the labour force were found to have the disease as a result of the screening program and the wages they would have obtained during the treatment period were used as a proxy for this output loss to society. Using census data for persons with similar characteristics, such as sex, race and location (for example, farm, non-farm, urban or rural), the following formula was employed to estimate the foregone earnings of these 38 patients:

$$\sum_{i=1}^{38} \left[(E_i)\,(R_i)\,(P_i)\,\frac{(H_i + 30)}{365} \right]$$

where E = the median incomes of labour force members having similar characteristics to the patients.

R = the employment rate of members of the labour force having similar characteristics to the patients.

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[76] This example is drawn from William B. Neenan, "Distribution and Efficiency in Benefit-Cost Analysis", *Canadian Journal of Economics* Vol. IV (May, 1971), pp. 216-24, and *Normative Evaluation of a Public Health Program* (Ann Arbor, Michigan: Institute of Public Administration, The University of Michigan, 1967).

P = the labour force participation rate of persons having similar characteristics to t patients.

H + 30 is the period of hospitalization together with an allowance of 30 days for phasi the patient back into the labour force following treatment.

Using this formula, the total loss in wages of those detected as having tuberculosis by t program was estimated to be $102,891. On the other hand, random detection of the disease in t absence of the program, and the associated *lengthier* treatment periods, would have resulted ir loss of wages of $113,859. The indirect benefit to society arising from the program was therefc the difference between these estimates of foregone output, or $10,968.

Finally, with the aid of an epidemiological model an estimate was made of external benef (direct and indirect) accruing to individuals who would not now be infected because of the earli detection of existing active cases of tuberculosis. This benefit stream extending into the future w discounted at a four per cent rate to yield a present value for external benefits of $42,281.[77]

The total of benefits from operating the screening program, or the sum of direct, indirect ar external benefits, was therefore $21,502 + $10,968 + $42,281 = $74,751. The costs of operating tl program were calculated to be $176,564. Accordingly, the net present value for the program w −$101,813, while the allocative benefit-cost ratio was 0.42.

In addition to evaluating the allocative effects of the program, its redistributive effects we also considered. A set of weights was constructed that illustrated the extent to which the screenir program favoured particular geographic areas.

If the objective of the program had been efficiency in the detection of morbidity, and redistr butive considerations had been unimportant, then for each i^{th} area the marginal investment benef (MIB_i) would have been equal to the marginal cost (MC_i) of the program. Thus,

(1) $MIB_i = MC_i$

In the presence of redistributive effects, the relationship changes to

(2) $(MIB_i)\ (MRW_i) = MC_i$

where MRW_i is the redistributive weight for the i^{th} area.

We can also define MIB_i as

(3) $MIB_i = (V_i)\ (MDR_i)$

where V_i = the value of one new case detected and MDR_i = the marginal discovery rate per 1,00 people screened.

Finally, substituting equation (3) into equation (2) and transposing,

(4) $MRW_i = MC_i/(V_i)\ (MDR_i)$

The marginal cost of discovering a new case of tuberculosis was estimated to be $666. Th value of V_i was found to be $1,525, or the total benefits of $74,751 arising from the progran divided by the 49 active tuberculosis cases detected. The marginal rates of discovery of tuberculosi

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[77] The present value of this benefit will obviously be smaller at the 10 per cent discount rate recommended by thi *Guide*.

in various locations are reproduced in the table below. Given this information, the redistributive weights for the various areas of the program shown in the table were calculated by using equation (4). In the table, the redistributive weights for the various areas are also expressed as a multiple of a base rate of unity in area D. The program clearly had redistributive effects, since the redistributive weights for areas other than D are not equal to unity.

TABLE 11

Discovery rates and shadow distributional weights for tuberculosis screening program

Area	(1) MDR, 1957-63 New cases found per 1,000 people screened	(2) MRW	(3) MRW as a multiple of base area D
A	0.66	0.66	2.0
B	0.69	0.63	1.9
C	0.01	43.56	132.0
D	1.32	0.33	1.0
E	0.30	1.46	4.4

The redistributional weights should not be interpreted as a deliberate deviation from efficiency objectives designed to improve the equity of the screening program. The weights could be indicative of a lack of flexibility in the program which prevented it from moving into new areas where the marginal rates of discovery of new tuberculosis cases would have been higher. As well, the redistributive effects may indicate the inappropriateness of the methods used to determine which areas required servicing.

APPENDIX I

INVENTORY OF COMMON ERRORS IN BENEFIT-COST STUDIES

The objective of this *Guide* is to propagate the use of benefit-cost analysis by federal government departments and agencies as an important input in making resource allocation decisions. While both the theory and practical applications of benefit-cost analysis have been discussed in great detail in the text, some of the most common errors to be avoided in benefit-cost studies are listed below:

Making allowances for changes in the general price level when estimating future benefits and costs

Anticipated changes in the general price level should be ignored in benefit-cost analysis to enable the analyst to focus on the benefits and costs in real, instead of nominal, terms. No allowances for anticipated inflation or deflation should be made.

Counting appreciated value of land relative to the general price level as a benefit

Even if land is anticipated to increase in value relative to other prices, it is wrong to include the increase in relative value as a benefit without taking into account increases in opportunity cost associated with keeping the land in the project.

Use of average, instead of marginal, benefits and costs

Allocative efficiency requires the consideration of marginal, not average, benefits and costs. For example, in calculating the operating costs of a new highway, marginal operating costs saved on alternative routes due to reduced traffic should be subtracted. Since operating costs can be expected to rise less than proportionately with the flow of traffic per unit of time, marginal operating costs will be lower than average operating costs. It often is the case, however, that only average operating costs are recorded, and the analyst adopts these averages for expediency. He should however be aware of the bias introduced – in the above example, the use of average operating costs will exaggerate the cost savings – and therefore sensitivity analysis should be performed.

Calculating costs net of government grants

It is typical of financial analysis from a private viewpoint to consider costs net of government grants. However, since total resource costs are relevant for benefit-cost studies of public projects, government grants must be considered as costs.

Including interest payments on borrowed capital as costs

Interest payments on borrowed capital, while being a financial outlay, have no significance as far as the economic costs of a project are concerned since the real resources used – labour, material, equipment, etc., are the same regardless of the source of financing.

Including depreciation in operating costs when costs of capital equipment have been included in a lump-sum fashion at the beginning of the project

Depreciation is strictly a bookkeeping device. To include depreciation on top of lump-sum capital costs will exaggerate real costs.

Routine application of shadow prices that are below market prices of resources on the grounds of unemployment

Project analysts should recognize that shadow pricing resources at less than market prices is justified only under special circumstances and not as a matter of course.

Routine assessment of multiplier effect of income and spending generated by a project on unemployed resources

Even when the use of unemployed resources is directly attributable to a project and thus the assignment of shadow prices is justified, analysts should recognize that the assessment of multiplier effects on idle resources elsewhere in the economy is beset by more theoretical and practical difficulties. Leakages to other sectors of the economy with fully employed resources must be estimated. Furthermore, since benefit-cost analysis involves comparing general welfare with and without a given project, the induced employment of otherwise-unemployed resources should not enter the calculations if it would have been generated by alternative expenditures displaced by the project.

Claiming benefits for a project that provides above-average job opportunities as manifested by an above-average wage rate

If it can be established that labour was under-utilized in alternative use, then wages paid by the project exceed the social opportunity cost of labour and thus labour benefits can be claimed for the project. However, the wage differential may simply be the result of different skill compositions, with the project hiring a higher proportion of skilled workers.

It cannot be assumed without empirical verification that the project provides superior jobs to previously under-utilized labour. An alternative, but equally inadequate argument for claiming this benefit is that the project provides on-the-job training. Not only does the analyst have to assure himself that on-the-job training has in fact been provided, but also that the increased wages represent a supra-normal return on the training costs incurred.

Subtracting wages paid to immigrant labour hired by the project on the grounds that immigrant labour is socially costless to use

The fact that a project draws on immigrant labour clearly should not make it more attractive. Traditional benefit-cost analysis focuses on the effects of a project on total physical production and consumption possibilities, given the stock of resources in the economy. With immigration, the stock of resources increases, thus automatically expanding the production possibilities, but the consumption opportunities for *Canadians* do not increase.

Choosing among projects on the basis of maximizing internal rates of return or benefit-cost ratios

The fundamental criterion for choosing among investment projects is the maximization of net present value. Ranking projects on the basis of either internal rates of return or benefit-cost ratios may lead to a sub-optimal choice.

Including transfer payments in benefits or costs

Transfer payments do not affect total production or consumption possibilities; they merely make someone better off at the expense of others and therefore should not be included in benefit-cost calculations.

APPENDIX II

ENGLISH-FRENCH GLOSSARY

Adequacy	Suffisance
Allocative effect	Effet d'affectation, d'efficacité
Alternative	Parti, variante, solution, possibilité
Alternative use	Autre emploi, autre usage
Benefit-cost analysis	Analyse avantages-coûts
Benefit-cost ratio	Rapport avantages/coûts
Binding constraint	Contrainte active
Cost(s):	
—opportunity	Coût d'option
—capital	Coût (frais) d'immobilisation
—maintenance	Coûts (frais) d'entretien
—operating	Coûts (frais) d'exploitation
—sunk	Coûts amortis
Cost-effectiveness analysis	Analyse coût-efficacité
Cut-off periods	Périodes-cadre
Discounted value	Valeur actualisée
Distributional effect	Effet de répartition
Effectiveness or Efficiency	Efficacité
External effects	Effets externes
Externalities	Externalités
Imputing values	Valorisation
Input	Intrant, facteur de production
Internal rate of return	Taux de rendement interne
Multiplier effects	Effets multiplicateurs
Leakage	Fuite
Low-income gap	Écart de faible revenu
Lumpiness (indivisibilities)	Indivisibilités

Opportunities:	
—consumption	Occasions de consommation
—production	Possibilités de production
Opportunity cost: see cost(s)	
Output	Extrant, production
Participation rate	Taux d'activité
Pecuniary effect	Effet monétaire
PPBS (Planning Programming Budgeting System)	RCB (rationalisation des choix budgétaires)
Present value	Valeur actuelle
Proxy	Indicateur
Proxy variable	Variable instrumentale
Scale economies	Economies de dimension,
Second-best theory	Théorie de l'optimum de second rang
Sensitivity analysis	Analyse de sensibilité
Shadow price	Prix fictif
Spillovers	Retombées
Social discount rate	Taux d'actualisation collectif
Social time preference rate	Taux de préférence intertemporelle collectif
Target group	Groupe visé
Target efficiency	Efficacité visée
Timing	Échelonnement, étalement
Trade-off	Arbitrage
Training:	
—institutional	Formation dirigée
—on-the-job	Formation sur le tas
Threshold	Seuil
Welfare economics	Économie du bien-être

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